Assessment of the City of Cape Town's Energy Efficiency programmes within its internal operations

by

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Declaration

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Abstract

The global climate crisis requires urgent action beyond the current policy framework and commitments, as currently made by a number of countries through the United Nations Framework Convention on Climate Change. Cities are known to be nodes of economic activity concentrating large populations and are carbon intensive due to the hive of activity within them. Cities contribute 75% of global carbon emissions. Cities therefore play an integral role in combating climate change. Local governments can lead by example through the implementation of energy efficiency and renewable energy initiatives within their own operations. The literature and case studies that were reviewed indicated that local government is implementing a number of energy efficiency programmes within their own operations. A gap remains in this area, as very few cities have made it "new business as usual" to drive and implement energy efficiency within their own operations. This study focuses on assessing the City of Cape Town's energy efficiency programmes within its own operations, with specific focus on understanding the outcomes that have been achieved. This study develops a business model to aid in continuation of energy efficiency programmes within the City of Cape Town, beyond the guaranteed funding period of 2017. The research methodology comprises a number of methods, including: a literature review, direct observations, and fieldwork to gather energy data used to develop the business model. The results indicate that a well-developed energy management system is integral to ensuring energy and climate targets are monitored and reported. The results indicate that Traffic Signal department and Specialised Technical Services department have adopted the new energy efficient technology and have changed to a new business as usual. The Electricity Services Department requires amending their store stock items to the energy efficient technology. A total investment of one hundred and sixty million rand has been achieved up until 2015. This has resulted in a total cumulative savings of one hundred and ten million rand up until 2014. The business model developed allows departments to follow a standardised process in setting energy targets, implementing energy efficiency measures and tracking financial, environmental and energy savings.

Opsomming

Die wêreldwye klimaatskrisis verg dringende aksie wat meer omvat as die beleidsraamwerk en ondernemings waartoe 'n aantal lande tans vanweë die Verenigde Nasies se konferensieraamwerk oor klimaatsverandering verbind is. Stede is bekende nodusse van ekonomiese aktiwiteit met 'n hoë bevolkingstal en is koolstofintensief weens die miernes van bedrywighede wat daar gekonsentreer is. Stede dra 75% tot globale koolstofvrystellings by. Gevolglik speel stede 'n integrerende rol in die stryd teen klimaatsverandering. Plaaslike regerings kan met hulle voorbeeld lei deur energiedoeltreffendheid en hernubare energie-inisiatiewe in hulle werksaamhede te implementeer. Volgens die literatuur en gevallestudies wat ondersoek is, implementeer plaaslike regerings 'n aantal energiedoeltreffendheidsprogramme in hulle werksaamhede. Daar bestaan 'n leemte in hierdie veld aangesien min stede die "nuwe-besigheid-soos-gewoonlik"-benadering volg deur energiedoeltreffendheid in hulle werksaamhede te dryf en te implementeer. Hierdie studie is gemik op die evaluering van die Stad Kaapstad se energiedoeltreffendheidsprogramme wat sy eie werksaamhede betref, en dit fokus veral op die insigte wat die uitkomstes opgelewer het. Die studie ontwikkel 'n sakemodel wat sal meehelp om die Stad Kaapstad se energiedoeltreffendheidsprogramme ná die verstryking van die 2017-waarborgfondstydperk te kan voortsit. Die navorsingsmetodologie omvat 'n aantal metodes waaronder: 'n literatuuroorsig, direkte waarnemings, asook veldwerk om energiedata te versamel vir die ontwikkeling van die sakemodel. Die resultate toon dat 'n goed ontwikkelde energiebestuurstelsel onontbeerlik is vir die monitering van energie- en klimaatsteikens en verslagdoening daaroor. Die resultate toon dat die Verkeerseindepartement en die Departement Spesiale Tegniese Dienste die nuwe energiedoeltreffendheidstegnologie aanvaar en na die "nuwe-besigheid-soos-gewoonlik"-benadering oorskakel. Die Departement Elektrisiteitsdienste vereis dat sy voorraadlokaalitems met energiedoeltreffende tegnologie vervang word. 'n Beleggingsinkomste van altesaam R160-miljoen is tot en met 2015 behaal. Die gevolg was 'n kumulatiewe besparing van altesaam R110-miljoen tot en met 2014. Die sakemodel wat ontwikkel is, maak dit vir departemente moontlik om 'n standaardproses te volg wanneer hulle energieteikens stel,

energiedoeltreffendheidsmaatreëls implementeer, en finansiële, omgewings- en energiebesparings naspoor.

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List of Acronyms and Abbreviations

AMI	Automatic Meter Infrastructure
CCT	City of Cape Town
CFL	Compact Fluorescent Lamp
DoE	Department of Energy
E&CC	Energy and Climate Change
EE	Energy Efficiency
ERMD	Environmental Resource Management Department
ESD	Electricity Services Department
LED	Light Emitting Diode
PV	Photovoltaic
RE	Renewable Energy
RSA	Republic of South Africa
STS	Specialised Technical Services
SRA	Sports Recreation and Ammenities
TSD	Transport Signal Department
WWTP	Waste Water Treatment Plant
UNEP	United Nations Environment Programme

1 Introduction

1.1 Background

Globally, governments are faced with challenges in meeting their international commitments to combating climate change, while delivering clean, safe, affordable energy to their citizens and, at the same time, driving economic development (Selvakkumaran & Limmeechokchai, 2013). Energy efficiency is deemed a low hanging fruit in combating climate change, while ensuring government's access to energy security (Matinga *et al*., 2014).

Cities in developing countries are faced with rapid urbanisation. According to the United Nations (UNDESA, 2014), Africa's urbanisation rate will rise by 21% and Asia by 52%, by 2050. Half of the world's population currently resides in cities, which has consequently contributed to 75% of global energy-related greenhouse gas emissions (Nations & Griggs, 2015). Cities are thus being recognised as a key role player in combating the international efforts against climate change (UNEP, 2014).

Cities can actively contribute to meeting national government targets relating to climate change by implementing mitigation measures, such as energy efficiency (Boza-kiss *et al*., 2013). Energy efficiency by nature is a decentralised activity, thus making local governments the appropriate agents to drive and implement energy efficiency (Rezessy *et al*., 2006).

The United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol were implemented in order to gain commitment from the global community to reduce their greenhouse gas emissions (IPCC, 2015). South Africa became a signatory of the Kyoto Protocol in 2007, and acknowledged climate change as a serious threat that will affect the country in the future (Winkler, 2005). Being a signatory to this treaty enabled South Africa to set a 42 percent emissions reduction target, to be achieved by 2025 (Republic of South Africa, 2007). This target led to the implementation of various programmes to reduce carbon emissions in South Africa (REN21, 2015).

The South African national government further set a national target for energy efficiency improvements of 12% by 2015 (Republic of South Africa, 2013a). The overall policy on energy efficiency is detailed in the National Energy Efficiency Strategy (Republic of South Africa, 2004) and Action Plan (Republic of South Africa, 2013a). While South Africa has a well-structured policy framework, which has enabled the growth of the renewable energy and energy efficiency sector, there remains a policy gap as the role of municipalities in implementing energy efficiency is not clearly defined (Republic of South Africa, 2013b).

The National Treasury introduced the Energy Efficiency Demand Side Management (EEDSM) grant in 2009, with a focus on supporting municipalities in upgrading their municipal infrastructure with energy efficient technologies (Republic of South Africa, 2009). The Department of Energy (DoE) was tasked with maintaining the municipal Energy Efficiency Demand Side Management (EEDSM) programme (Republic of South Africa, 2004). This national municipal Energy Efficiency Demand Side Management grant has been a catalyst in enabling municipalities to recognise the potential of energy efficiency programmes in reducing their internal operations electricity expenditure by upgrading their ageing infrastructure (Republic of South Africa, 2009).

The overall success of the national municipal Energy Efficiency Demand Side Management programme is, however, not known as there is no coordinated monitoring and evaluation of the entire programme (Sebitosi, 2010). Similarly, the impact of the energy efficiency programme within municipalities' internal operations is not clear because most of the municipalities that participated in the programme lack the capacity to implement these programmes. This leaves the following questions: i) Can the municipalities continue implementing energy efficiency programmes when the grant term is over? And ii) would the municipalities have implemented the necessary mechanisms to sustain the savings of past and existing energy efficiency projects by the time the grant term is over?

These research questions stem from the author's role as the City of Cape Town's representative at the national Department of Energy's municipal Energy Efficiency

Demand Side Management meetings, as well as the one tasked with driving energy efficiency within the City of Cape Town's internal operations. The author's interest in driving and embedding a sustainable energy efficiency programme within the City of Cape Town's internal operations, together with the complexities faced during implementation and engagement with national government in the municipal Energy Efficiency Demand Side Management programme, provided the motivation to reflect on the problem and conduct this research. The focus of this research was on the City of Cape Town's energy efficiency programme within its internal operations.

The City of Cape Town is known to be pro-active and a leading municipality when it comes to energy and climate change policies and projects (Ekurhuleni, 2010a). It has a dedicated Energy and Climate Change Unit housed within the Environmental Resource Management Department. The Energy and Climate Change Unit plays a strategic role by developing key policies and strategies to assist the City of Cape Town in developing an effective energy and climate change framework (City of Cape Town, 2006). This framework aims to steer development within the City of Cape Town to be low in carbon emissions, resource efficient and to ensure alignment with national policy (City of Cape Town, 2006).

The City of Cape Town has an Energy and Climate Change Strategy (City of Cape Town, 2006) and an Energy and Climate Change Action Plan (City of Cape Town, 2011) which forms the policy framework for all energy and climate change programmes (Cartwright, *et al*., 2012). The Energy and Climate Change Action Plan (ECAP) set a target of "10% reduction in energy consumption by 2012" (City of Cape Town, 2011). The City of Cape Town, through its rigorous monitoring and reporting system, achieved a 12.8% saving against the target set in the Energy and Climate Action Plan, as verified by independent auditors (Cape Town, 2015a) .

This has allowed the City of Cape Town to lead by example through its internal operations energy efficiency programme. Leading by example enables the City of Cape Town to support green economy markets and to encourage key sectors, such as residential and commercial sectors, to actively pursue a reduction in their energy consumption (IEA, 2013; World Energy Council, 2013). In order for the City of Cape

Town to become energy efficient within its own operations, it requires a business model, which will enable all departments to follow a uniform process of implementing energy efficiency. Yet, there is currently no business model to enable departments to implement energy efficiency. This is due to historically cheap electricity in South Africa. A business model is required in order to sustain the current energy efficiency programmes and to ensure that all line departments prioritise and move from using energy intensive infrastructure to using energy efficient technologies (World Energy Council, 2013).

1.2 Problem Statement

Grant funding and subsidies from the South African Department of Energy to support municipal energy efficiency programmes, stimulated the implementation of energy efficiency programmes in South Africa (Republic of South Africa, 2009). However, the funding for these programmes has only been guaranteed until 2017/18 (Republic of South Africa, 2013c). It is unclear whether government will continue supporting this programme beyond the guaranteed period. Furthermore, the energy efficiency programmes at the municipal level have been implemented on an ad hoc basis. It is not a requirement for participating municipalities in the Energy Efficiency Demand Side Management programme to demonstrate that they have set in place the necessary systems and processes to continue implementing energy efficiency programmes in the absence of the grant funding. Municipalities are not required to prove that they have systems in place to maintain the new efficient technologies by procuring the necessary efficient technologies and holding it as part of their store stock items. It is thus essential to examine the uncertainty around grant funding to support energy efficiency at the municipal level, and to emphasise the importance of developing a business model to inform and facilitate future energy efficiency programmes.

1.3 Research Objectives

This study aims to answer the following research questions:

1. To what extent have the current energy efficiency programmes been implemented in the City of Cape Town’s internal operations?
2. What are the benefits and challenges for implementing energy efficiency programmes in the City of Cape Town’s internal operations?

3. What is the business model needed in order to enable the implementation of energy efficiency programmes within the City of Cape Town's internal operations beyond the guaranteed funding period?

1.4 Research Limitations

The scope of this study was limited to the City of Cape Town's internal energy efficiency operations programme. Most of the energy efficiency programmes implemented focused on making electricity usage more efficient, therefore the core focus of this research was on street, traffic and building electrical efficiency programmes. The outcomes of this study might not be generalizable, as the organisational context of other cities differs from that of Cape Town. The City of Cape Town is a metro and therefore some of the outcomes obtained in this research might not be applicable to district municipalities elsewhere in South Africa, as they have different institutional arrangements.

1.5 Chapter Outline

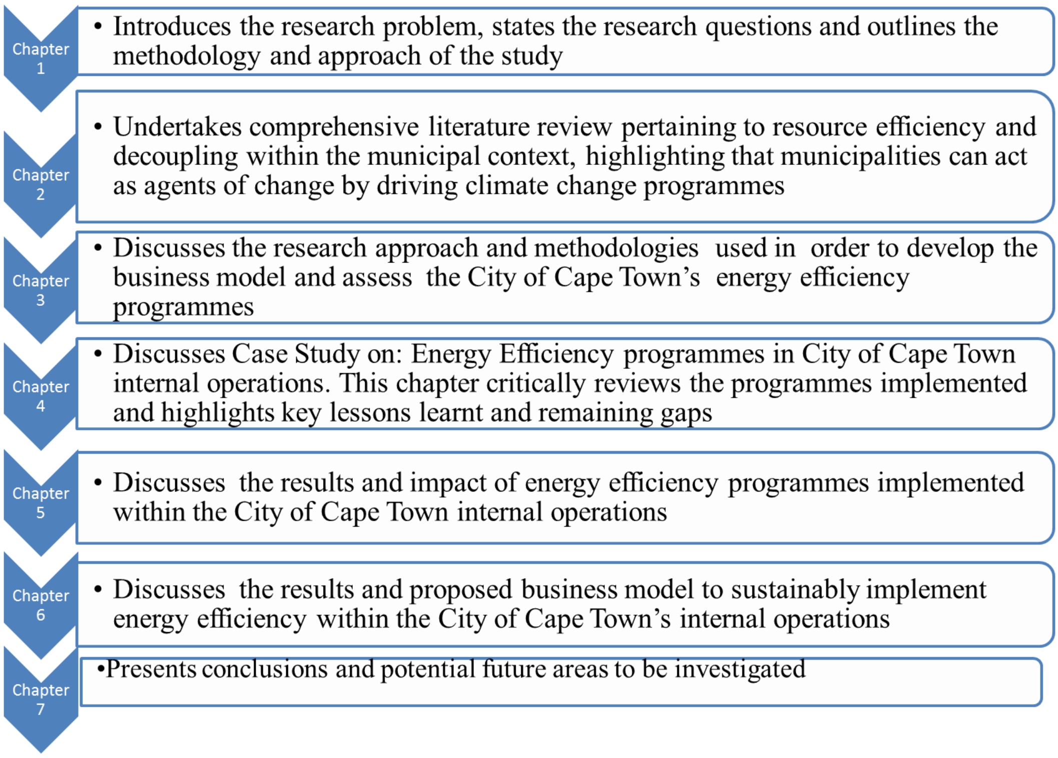

Figure 1.1: Depiction of thesis chapter outline

2 Literature Review

2.1 Introduction

Scientific evidence of the depletion of natural resources, increased severe storms, droughts and global food shortages, are all signs that the earth is reaching its bio-capacity (Global Footprint Network, 2011). These events and facts have not, however, been enough to cause world political leaders to recognise the crisis and take any action until the historical 1970s oil crises occurred (Bardi, 2009).

The 1970s oil crises ensured that world political leaders took action and acknowledged that global resource constraints pose a serious challenge worldwide. It became evident that current excessive consumption could not be sustained in the future, with an exponential growth in future population predicted (WWF, 2014). This event initiated key global debates and led to the development of the term sustainable development, defined by the Brundtland Commission report (1987) as “development which meets the needs of current generations without compromising the ability of future generations to meet their own needs”

Energy efficiency has been hailed as low hanging fruit as it makes financial sense, contributes to lower maintenance costs and assists in achieving climate mitigation targets (Selvakkumaran & Limmeechokchai, 2013: 491–503). The benefits of implementing energy efficiency programmes are well known, however, the uptake of energy efficiency programmes remains slow across a number of sectors, especially government (Reddy, 2013: 403–416).

This literature review examines the theory of factors governing energy efficiency with a particular emphasis on energy efficiency within the municipal sector. This chapter highlights the key policies driving energy efficiency globally, and the successes, gaps and challenges experienced by these municipalities. This section concludes with an overview of the South African energy efficiency policy framework, with examples of the manner in which local authorities define their roles as municipalities with regards to implementing energy efficiency.

2.2 Global perspective on energy efficiency

It is important to define the term energy efficiency and the associated key terms used in the field of energy efficiency. Energy efficiency is defined as the ratio of input energy required and the service output produced (Proskuryakova & Kovalev, 2015). This view is supported by Pérez-lombard *et al*. (2013) Reichl & Kollmann (2016), Oikonomou *et al*. (2009), Trianni *et al*. (2014) and Fleiter *et al*. (2012), amongst others. Conversely, the World Energy Council (2008) defines energy efficiency as the reduced amount of input energy for a required amount of output energy to do work (World Energy Council, 2008; Oikonomou *et al.*, 2009; Pérez-lombard *et al.*, 2013). This study follows the World Energy Council's (2008) definition, because it clearly defines what is meant by energy efficiency.

Energy intensity is another key term used in the context of energy efficiency, and is defined as the reduced amount of input energy needed to deliver one unit of GDP (Fleiter *et al.*, 2012). Energy savings is defined as the reduction of energy achieved, as defined by (Pérez-lombard *et al.*, 2013) and confirmed by (Oikonomou *et al.*, 2009). Energy conservation is defined as using the required energy for the specific or desired work to be achieved, and is also known as energy sufficiency (Oikonomou *et al.*, 2009). Energy performance describes the quality of functioning of a system pertaining to its energy use (Pérez-lombard *et al.*, 2013). Green procurement is defined as a "procurement system with the intent to maximise its benefits and minimising its disadvantages to the natural environment and associated resources, thereby promoting environmental sustainability by applying it to the procurement processes" (Testa, Annunziata, Iraldo & Frey, 2016: 1893–1900).

Global concerns about climate change and energy security have prescribed that future climate and energy needs require specific interventions in order to address these concerns. Energy efficiency is but one of these interventions. It is quick to implement and is able to achieve significant results by reducing energy consumption, carbon emissions and improving the environment (IPCC, 2015).

Energy efficiency improvements also assist countries and utilities to expand their customer base without having to increase their production capacity. The reduced demand therefore assists with keeping expansion investment into the electricity sector low, which would otherwise be a huge constraint for developing countries experiencing rapid growth (Sebitosi, 2008; World Energy Council, 2013). The World Energy Council (2013) emphasises that the public sector, especially local authorities, have to lead by example, and that local authorities have proven to be key agents in supporting the development of Energy Services Companies (ESCO's). Furthermore, they assisted in establishing the need in the market for efficient goods and services through their large buying power and procurement processes (World Energy Council, 2013). Studies conducted by the International Energy Agency (2014), World Energy Council (2013) and Intergovernmental Panel on Climate Change (2015) on the policy framework required to support energy efficiency does not explain or illustrate what institutional framework is required at local government level in order to ensure that effective energy efficiency and renewable energy policy is created and enforced. Journal articles have been reviewed as part of the literature review process and it is presented in section 2.3 page 26 which illustrates the gap within the literature persists around which institutional models are required at a local government level to standardize energy efficiency within its own operations (Annunziata *et al.*, 2014: 364–373.

Voigt *et al*. (2014) reviewed the energy intensity of forty major economic countries in order to identify the key drivers needed in order to reduce the energy intensity of countries. The study highlights the fact that technological change has been a key driver across the sample of forty countries assessed, and that structural change, defined as countries shifting to less energy intensive sectors, has not been a major driver across the study sample (IEA, 2013; Voigt *et al.*, 2014: 47–62). The overall improved energy intensity levels achieved globally have been driven by technological improvements (Voigt *et al.*, 2014: 47–62). A significant shortcoming of the study is that it did not clarify the reason that most countries are heavily focused on driving energy efficiency through technological change. Furthermore, the study did not clarify whether government policies focused on structural change would lead to higher improved energy intensity outputs (Voigt *et al.*, 2014: 47–62).

Energy efficiency has multiple benefits at an international, national, sectoral and individual level, as illustrated by studies of the International Energy Agency (2014); Yang (2013); and the World Energy Council (2013); amongst others. Transport and buildings remain the largest sectors which can contribute to the energy intensity of countries globally, as illustrated in Figure 2.1 (World Energy Council, 2013).

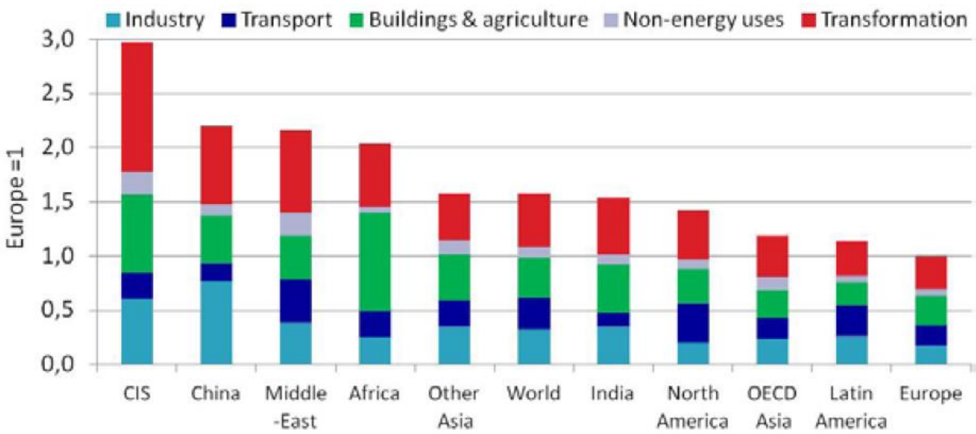

Figure 2.1: Sectoral contribution to primary energy intensity

Source: World Energy Council (2013)

The acronym CIS in Figure 2.1 stand for Community of Independent States, which comprises Eastern European countries such as Azerbaijan, Armenia, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Russia, Tajikistan, Turkmenistan, Uzbekistan and the Ukraine (World Energy Council, 2008). Policy remains the largest focus and driver enabling energy efficiency globally (World Energy Council, 2013). The World Energy Councils (2013), as well as the International Energy Agencies (2014), report on the multiple benefits of energy efficiency and echo the importance of effective policies to drive energy efficiency. Barriers to energy efficiency policy remain the lack of enforcement of regulatory policy mechanisms and the lack of financial incentives available, in order to support and ensure continuous implementation of energy efficiency measures (Schultz & Eto, 1990; Reddy, 2013: 403–416; Trianni *et al.*, 2014).

Local government can play a key role and lead by example. This would require that local authorities develop and implement energy efficiency action plans and strategies to drive energy efficiency (Kona *et al.*, 2015).

Table 2.1: Dominant global policy mechanisms in place to drive energy efficiency

	Energy Efficiency Targets	Regulatory Policy	Fiscal Incentives and Public Financing
Policy Mechanisms	Sectoral Targets	Standards • Labelling • Minimum energy performance standards	Grants
	Total Consumption Targets	Taxes	Capital subsidy/Rebates
	National EE laws	Subsidies	
	Energy Efficiency agencies	Mandatory Energy Audits	
		Mandatory Training of Energy Efficiency Professionals	
		Mandatory Communication to enable EE behaviour change	
		Mandatory energy managers	
		Mandatory energy consumption reporting	
		Mandatory energy savings plans	

Source: World Energy Council (2013) and International Energy Agency (2012)

A study by Boza-Kiss *et al*. (2013: 163–176) focused on energy efficiency policy pertaining to buildings, and identified global key policy trends which could be used as international best practice in order to drive energy efficiency in buildings. According to Boza-Kiss *et al*. (2013: 163–176) the results of the study confirm and support the findings of the WEC (2008) and Scholmann *et al*., (2012); that regulatory policy for buildings remains the most effective measure for driving energy efficiency in buildings. Table 2.1 illustrates the key policy mechanisms available for energy efficiency programs (REN21, 2015). The study also re-iterates that local government's role is two-fold, in that they are able to not only drive down their energy consumption and cost, but also have a key role to play by using their procurement processes to support and develop the energy efficiency market (Boza-Kiss *et al.*, 2013: 163–176).

The study conducted by Boza-Kiss *et al*. (2013: 163–176) stresses the need to raise awareness and use communication as a means of informing users of their consumption and ways of reducing that consumption. The key shortcomings, which the authors raise, is the lack of a cost-comparative study on global energy efficiency policies, which will be useful for countries in order to assess and compare all factors (Boza-kiss *et al.*, 2013: 163–176).

A good example of an integrated, intra-government and co-ordinated supporting policy, is that of the European Union's Energy Efficiency Directive (2012), which has defined the role of municipalities and has enforced action throughout the European Union's Covenant of Mayors policy (Cerutti, Iancu, Janssens-maenhout, Melica, Paina, *et al.*, 2013). The Covenant of Mayors requires Mayors of municipalities to set targets and put plans in place to support the European Union's Energy Efficiency Directive on climate change (European Parliament, 2012). The Covenant of Mayors (2013) has proven to be very effective, in that most municipalities across Europe are actively implementing and driving both energy efficiency and renewable energy at the level of local authority (European Parliament, 2012).

The European Union has an overall monitoring and reporting programme in place, which keeps track of the progress of the overall programme (European Parliament, 2012). The European Union has set a target to achieve 20% energy efficiency by 2020. A study on the progress of the programme indicated that the European Union is well on target (Gómez-calvet, Conesa, Gómez-calvet & Tortosa-ausina, 2014). The Covenant of Mayors literature does not state if those cities that are signatories to the Covenant of Mayors have established teams or dedicated specific personnel to drive resource efficiency in the municipalities, or if most of the cities that have joined already had existing staff dedicated to working on resource efficiency. Staff is one major barrier for most municipalities in driving change and utilising resources efficiency.

2.3 Experiences of local authorities leading by example globally

Annunziata *et al*. (2014: 364–373) investigated the impact of using a regulatory mechanism, such as local energy audits in municipal buildings, and the factors that need to be addressed critically in order to ensure effective implementation by local authorities.A total of 322 municipalities across Italy formed part of the study. Statistical methods were used to analyse the data, in order to determine the key driving factors that local authorities should focus on and improve (Annunziata *et al.*, 2014: 364–373). The study highlights that capacity, capturing and transferral of information, as well as the retention of knowledge, are key factors that impact decisions to be made within a local authority. Developing and retaining knowledge at the level of local authority, is a crucial factor to be addressed if effective energy efficiency within municipal buildings is to be achieved (Annunziata *et al.*, 2014: 364–373; Cilliers, 2005a).

The study's results confirmed that municipal officials who received training on the principals of energy efficiency contributed to the implementation of further energy efficiency interventions in the municipality, as did conducting an energy audit (Annunziata *et al.*, 2014: 364–373). Champions' driving energy efficiency as well as the transferral and retention of knowledge within the municipality is another crucial aspect required, in order to ensure that long term sustainable plans for energy efficiency are executed. (Cilliers, 2005a; Annunziata *et al.*, 2014: 364–373).

Energy audits, as regulatory mechanism at the local authority level, are effective, but only in conjunction with the training of municipal officials. WEC (2013), IEA (2014) and UNEP (2014) all confirm that municipal authorities, by using their buying power through the implementation of sustainable public procurement, can shift the traditional procurement evaluation system from a pure cost basis to a lifecycle basis. This can contribute significantly to the implementation of efficient technology and services within a local authority (World Energy Council, 2013). Annunziata *et al.*, (2014) points out some important gaps in the literature which require further investigation, namely which policy instruments are most effective at the local authority level and the manner in which local municipal budgets need to take the impact of energy efficiency into consideration. Annunziata *et al*., (2014) offers by far the most comprehensive literature on implementing energy efficiency from a local government perspective. It highlights key aspects required, but also points out the gaps that are linked to municipal policy. This study also points out that the way, in which the institutional organisation adopts and structures itself to support and drive energy efficiency, needs further investigation.

Figure 2.2 summarises the key points by Annunziata *et al*., (2014: 364–373).

Figure 2.2: Illustration of key factors contributing to knowledge management in the municipal context

Source: Annunziata, *et al*. (2014)

According to Radulovic *et al*. (2011: 1908–1915), public and building lighting energy efficiency programmes within local governments are easy to implement interventions which are cost effective and contribute to improvement of public services and national government's climate change commitments. The City of Rijieka, Croatia, used an energy management approach to implement a public lighting programme (Radulovic *et al*., 2011: 1908–1915). Their programme retrofitted inefficient streetlights and they implemented a campaign to raise awareness and share the results of their program with residents and the business community.

The aim of the awareness campaign was to create knowledge and understanding around energy efficiency. By sharing the savings achieved by the retrofit programme, the City of Rijieka aimed to encourage its residents and business community to pursue energy efficiency measures within their own homes and businesses (Radulovic *et al*., 2011: 1908–1915). This was successful as the local authority succeeded not only in reducing its energy consumption and expenditure, but also in using its authority and capacity to educate and stimulate change within its immediate environment, hence leading by example. The public lighting programme also used its procurement purchasing power as an opportunity to support the procurement of efficient technologies (Radulovic *et al.*, 2011: 1908–1915). A local authority's buying power can transform and stimulate the energy efficiency market (Boza-kiss *et al.*, 2013: 163–176; Annunziata *et al.*, 2014: 364–373). The study by Radulovic *et al.*, (2011) however, does not state what kind of energy efficiency communication programme they implemented and for how long they kept the campaign running in order to achieve successful support by the public. In order to sustain savings from behaviour change, continuous and frequent messaging and training are required (Griffiths,2012; Kusakabe, 2013: 1–65).

Another example of the way in which local authorities can contribute and support national governments in achieving their targets relating to energy efficiency, is represented by Zheng *et al*. (2013: 646–655). Their study reviewed three local authorities that assisted in enforcing mandatory regulatory policy on energy efficiency standards and labelling programme for appliances and equipment in China. The role of the local authority in this study was to create awareness and illustrate the benefits of using energy efficient appliances to its local residents (Zheng *et al.*, 2013: 646–655). The study highlights the need for policy to clearly define the roles of all actors in order to achieve greater enforcement of national policy goals and the need for intra-government collaboration (Zheng *et al.*, 2013: 646–655).

It has been established through many studies, for example Borg *et al*. (2006), Michelsen & Boer (2009), Rezessy (2006) and Reddy (2013), that local authorities have the ability to drive and support the development of energy efficiency markets through the procurement of energy efficient goods and services (Borg *et al.*, 2006; Michelsen & Boer, 2009). According to Michelsen & Boer (2009: 160–167) in order for green procurement to be established and practiced by a local authority the procurement department would require expert input, in order to develop a green procurement strategy. Furthermore, in order to ensure a functioning and well implemented green procurement strategy, the development of staff capacity through training is required (Michelsen & Boer, 2009: 160–167). Table 2.2 has been adapted to capture and incorporate several key barriers experienced at the municipal level as defined by Rezessy *et al* (2006: 223–237).

Table 2.2: Barriers and recommendations to implement energy efficiency in the municipal context

Barriers	Recommendations
Energy related task, responsibilities and roles are not clearly defined	Policy required to clearly define the roles and responsibilities of municipalities pertaining to energy efficiency
Savings cannot be retained	Policy to be amended and allow municipalities to retain and re-invest savings into further energy efficiency programmes
Public procurement policies are not supportive of energy savings projects implemented by Energy Services Companies	Procurement Policy needs to be amended to support shared savings contracts
No or limited government grant supporting energy efficiency at the local authority level	National government grants or soft loans are required to initiate energy efficiency at the local authority level
Skilled and dedicated staff required to drive energy efficiency within a municipality	Dedicated skilled staff need to be appointed
The need to set and develop targets and strategies	An energy efficiency strategy with targets needs to be established
A co-ordinated approach and monitoring programme is required	An overall monitoring and reporting programme needs to be set in place before the commencement of a programme

Skills to conduct energy efficiency audits internally	Technical staff required to conduct energy audits

Source: Rezessy *et al.*(2006); Michelsen & Boer (2009); Radulovic *et al.* (2011); Boza-kiss *et al.*(2013); Reddy (2013); Zheng *et al.*(2013); Annunziata *et al.* (2014)

In order to drive energy efficiency at the municipal level, sustainable energy and climate change strategies are required (Fenton, Gustafsson, Ivner & Palm, 2014: 1–9). This requires political drive and buy-in from municipal officials (Fenton *et al.*, 2014: 1–9). The success achieved in thecase study presen ted by Fenton et al., 2014 revealed that the organisational structure adopted within the local authorities, of which stakeholder engagement and participant input, was instrumental in achieving the targets set out in the strategy (Fenton *et al.*, 2014: 1–9).

The examples reviewed in section 2.3, of the various global municipalities' experiences, has highlighted some interesting and similar challenges, currently experienced by South African municipalities with regards to implementing and driving energy efficiency at the municipal level. The literature does not state the cost of developing and training staff in the field of energy efficiency, or the return on investment for training staff in this field, but this would also be dependent on the local context. This is a gap identified by the author in the literature reviewed, from the perspective of local government. This section provides insight and assists the author in answering questions 1 and 2 of the research problem in this thesis.

2.4 Resource efficiency and decoupling at the municipal level

The global population is currently estimated at 7 billion, with a future estimated trajectory of 9 billion to be reached by 2040 (UNDESA, 2014). More than half of the world's current population resides in cities (UNDESA, 2014). There is no general consensus on the definition of megacities. However, for the purposes of this paper we will adopt the United Nation's definition, which defines a megacity as a city that houses a population of 10 million or more residents, according the United Nations (2014) world urbanisation report. In 1990, there were 10 megacities globally; the majority of which were in the global north (UNDESA, 2014). A decade later, the number of megacities has approximately tripled, to 28, with a growing number located in the global south (UNDESA, 2014). It is forecasted that by 2030 the number of megacities will increase by 30%, resulting in 41 megacities globally, with most of these new megacities in Asia and Africa (UNDESA, 2014).

The population of the City of Cape Town was 3.9 million in 2015, and it is projected that by 2030 the city could have a population of 10 million (Cape Town, 2015a). Whilst Cape Town is not projected to be a megacity, it will continue to face an increase in urbanisation in the future. This increased rate of urbanisation is an opportunity for cities to plan more effectively, and to manage and implement effective sustainable development policies to ensure that equitable access to services and employment is achieved. This will also require competent local governments with a capacity to utilise intelligent communication systems, innovative approaches and integrated methods in order to deliver better services (UNDESA, 2014).

The earth's natural resources underpin our economic activities and are essential to human wellbeing. According to the United Nations' millennium eco-system assessment report (2005), 60% of the world's eco-systems are degraded. This endangers the future wellbeing of humans, as we are primarily dependent upon our eco-system for food, fuel and water. This degradation is directly linked to the rapid population growth and need to provide these essential resources for human survival (Writing *et al.*, 2005).

Population growth has increased economic activity and has increased the demand on the earth's natural resources and energy (Timothy Moss, Marvin & Guy, 2012). Resource decoupling is defined by UNEP (2011) as the increase in economic activity with the use of less resources and minimal impact on the environment, while contributing to the positive development of human wellbeing, as illustrated in Figure 2.3 (UNEP, 2011).

Krausmann *et al*. (2009) studied the global material flow from 1900 to 2000. The study illustrates that, although global population has increased, material extraction and economic activity has increased. The study reveals that the global metabolic rate, which is defined as the average use of materials per capita, has increased steadily

(Krausmann *et al.*, 2009). Figure 2.4 and Figure 2.5 illustrate the first graphical depiction of the concept of resource decoupling. From the 1970s a distinct accelerated increase in GDP occurs, while materials extraction continues to rise at a lower rate (Krausmann *et al.*, 2009). Krausmann *et al.* (2009), through their study, illustrate that efficiency gains of 0.68% per year and 1% material efficiency gains were recorded between the year 1900 and 2005. This is attributed to efficiency gains through technological advancements, due to the oil crises experienced in the 1970s (Krausmann *et al.*, 2009).

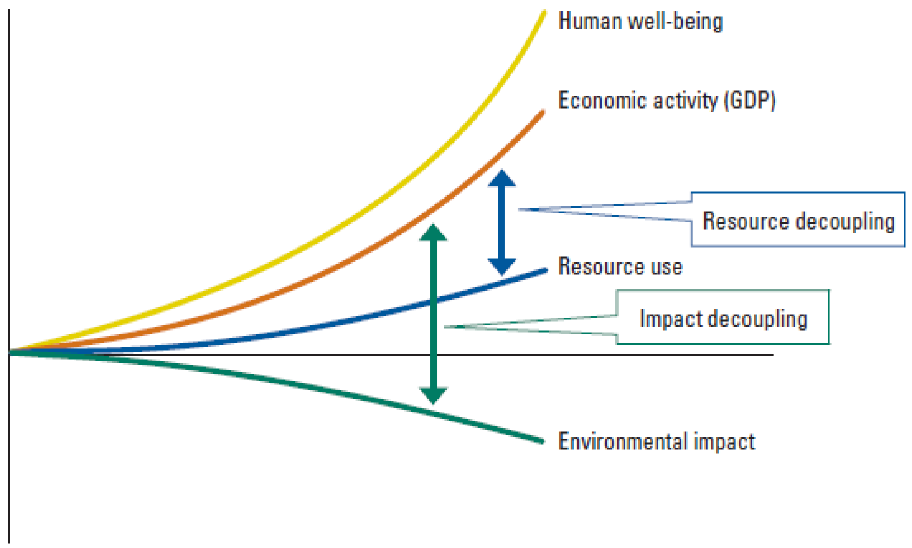

Figure 2.3: Illustration defining the term resource decoupling by UNEP

Source: UNEP (2011)

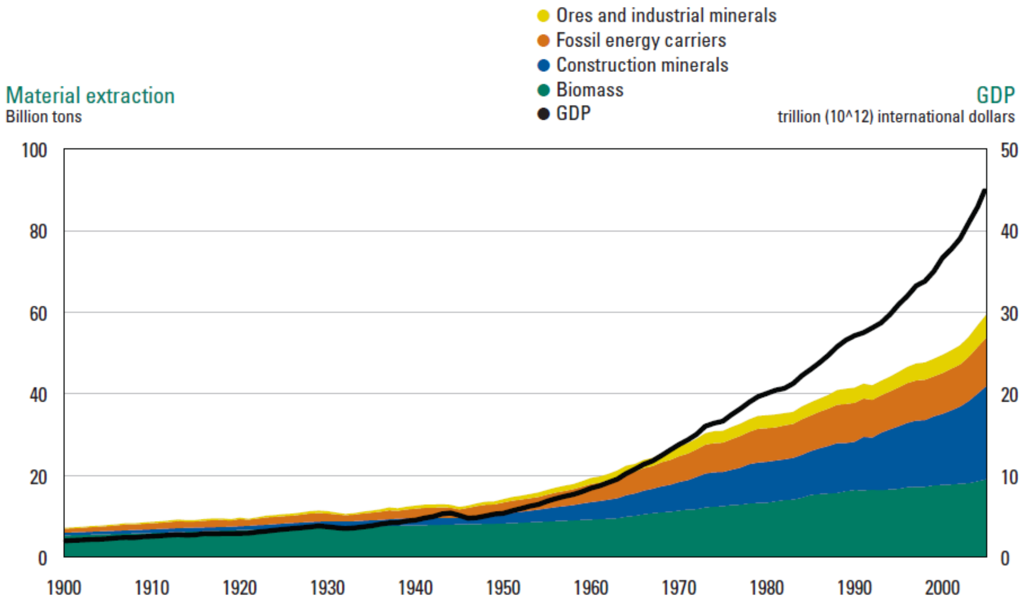

Figure 2.4: Global materials extraction compared to GDP

Source: Krausemann *et al*. (2009)

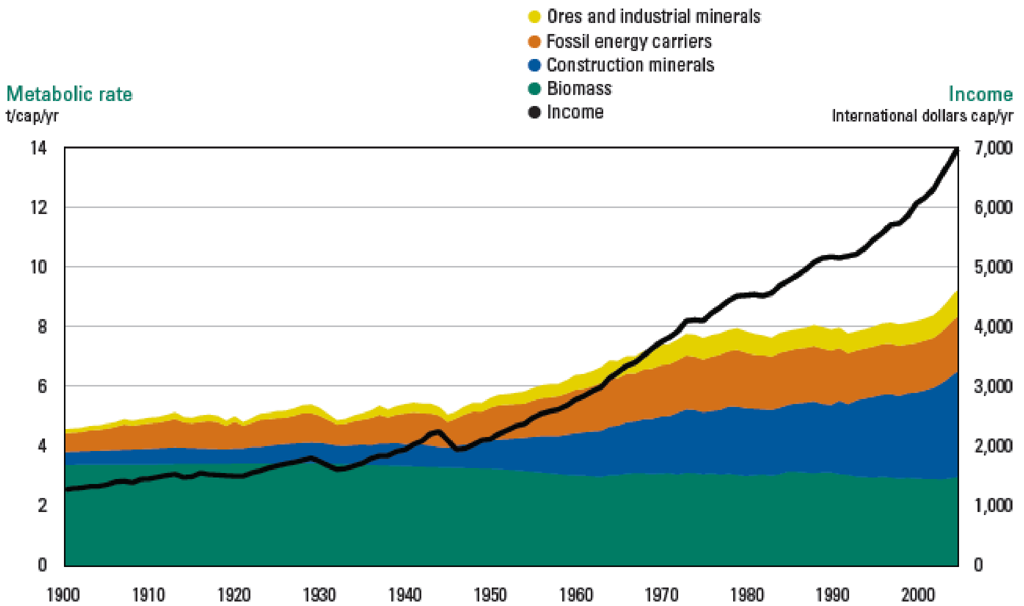

Figure 2.5: Global metabolic rates vs. income

Source: Krausmann, *et al*.(2009)

The study of Krausmann *et al*. (2009) also illustrates that developing countries with a high population density such as India and China, has a metabolic rate of 5 tonnes/capita/year, while low population density developing countries (for example, South Africa) have an average of 12 tonnes/capita/year. Developed countries with a high population density (for example, Japan) have a metabolic rate of 13 tonnes/capita/year as opposed to low population density developed countries (for example, USA) with a rate of 24 tonnes/capita/year (Krausmann *et al.*, 2009).

The UNEP (2011) report echoes the important role that cities will play in energy conservation, and while they currently contribute to the unsustainable use of resources, they host huge potential to drive sustainable resource use in the future. A local authority as an entity, is mandated with delivering sustainable services, and therefore has a responsibility to lead by example, and to develop policies that require its residents and business to become more resource efficient. According to Swilling & Annecke (2012), decoupling is not factored into many city planning processes in an effort to becoming more resource efficient, which results in unsustainable development (Swilling & Annecke, 2012). This is the result of the fact that municipal planners do not see the long-term benefits of resource efficiency, and it is also not seen as their role to be driving resource efficiency.

The focus of the present study is on the municipality as an entity. Energy efficiency contributes to resource efficiency. Assesing the impact of energy efficiency programmes within the internal municipal operations, it can be determined whether decoupling is occurring from the perspective of electricity consumption. As municipal service delivery increases to meet resident requirements, it can become more resource efficient in the way it delivers those services (Hyman, 2011). This section assisted in answering question 1 and 2 of the research problem in this thesis.

2.5 Understanding the role of South African municipalities through a complex systems theory lens

There is no consensus in the scientific world on the definition of complexity (Manson, 2001: 405–415). Complexity is derived from the Latin word “complexus” which means woven together (Byrne, 2009: 1–6). Drawing on Byrne’s (2001: 61–76) working definition, a complex system can be defined as an open system which allows constant interaction between various elements which are not in equilibrium, and which evolves to another state over time. This definition is supported by Cilliers

(2004: 1–4); Manson (2001: 405–415) and Loorbach (2010: 161–183). This constant feedback response makes it inherently difficult to underpin the root causes of systems and requires a creative approach when dealing with such complex systems (Byrne, 2009: 1–6) supported by (Morin & Kelly, 1977; Cilliers, 2005a).

Properties of a complex system

The properties of a complex system have been defined by a number of authors such as Rotmans & Loorbach (2009), Morin (1977), Byrne (2001), Cilliers (2005a), Corfield (2006) and Cilliers (2004: 1–4). The following summary presents the properties of a complex system:

i. Must consist of a large number of variables of which the closest variables will have strong interactions
ii. These variables must interact with one another in a dynamic way
iii. This interaction changes over time and can be physical or through the transfer of information
iv. Complex system has a history which impacts its current state
v. The interaction between variables is non-linear
vi. This non-linearity allows small causes to have substantial impacts
vii. The rich interaction between variables which is non-linear gives rise to patterns which result in emergent properties of the whole system
viii. The constant interaction results in feedback loops which can be positive and negative
ix. Interaction with its environment makes it an open system
x. Complex systems operate in non-equilibrium conditions

Identifying these properties allowed this researcher to develop the most appropriate business model required for the research problem. Cilliers (2005b: 605–613) further states that complex systems cannot model all variables and that models are therefore imperfect, but are necessary if we want to understand complexity. Cilliers (2005b: 605–613) further states that models of complexity must be revised constantly, as the system is open and experiences constant change. Cilliers (2004: 1–4) concludes by stating that complex models are imperfect and that there will always be a gap between the model and complex systems, and that this gap requires constant revision if we want to narrow the gap to achieve more accurate models.

Understanding relationships within complex systems

Identifying the properties of a complex system provides greater insight with respect to the relationships within complex systems. Cilliers (2001: 135–147) states that the "relationship among the components of the system are usually more important than the components themselves". Properties are exhibited through behaviour, which impacts relationships within a system. Schiuma, Carlucci & Sole (2012: 8044–8050) state that the value in a systems thinking approach is that it enables decision makers "to explore not only the causal relationships between variables but also to develop a holistic understanding of how the relationships can dynamically evolve over time". Similarly to Tshela and Cilliers applying a complex systems theory lens to the problem statement assisted the author in understanding the role of the relationships between departments and the manner in which this ultimately shapes and impacts on the internal energy efficiency programmes within the City of Cape Town (Cilliers, 2004: 1–4; Tshehla, 2014). The City of Cape Town is a highly complex organisation in which internal processes are governed by the Constitution (1996) and the Municipal Structures Act (Republic of South Africa, 1999) which is further elaborated on in section 2.6.

Cilliers (2005b: 605–613) states that, when dealing with a system, the application of a boundary is necessary in order to identify the system. Richardson & Lissack (2001: 32–49) defines a boundary as "the domain of effort through which an organizational entity interacts with its environment". Cilliers (2001: 135–147) warns us to not think of boundaries as physically demarcated bounds, but rather as a change in phase, bearing in mind that complex systems are open and are constantly interacting with their environment. Boundaries of complex systems are therefore emergent and temporary (Richardson & Lissack, 2001: 32–49), supported by Cilliers (Cilliers, 2001: 135–147).

With this complexity in mind, it is important to define the system's boundary for the purposes of this research, which focuses on the municipality as an entity and which further focuses on the internal energy efficiency programmes. This boundary will also be extended to the Department of Energy as it encourages municipalities to upgrade their infrastructure to become energy efficient. Acknowledging both Cilliers (2001: 135–147) and Richardson & Lissack (2001: 32–49) and their description of complex systems, and defining the boundaries of these systems, the author acknowledges that there are many other influencing factors within this system. The author also wishes to state that this interpretation of the municipal internal energy efficiency operations of the City of Cape Town is the author's understanding of the system, and acknowledges that other factors in the system boundary of this study exists, and do impact the research system.

The importance of ethics within complex systems

This research focuses on the City of Cape Town, which is a municipality. In order for the City to meet its constitutional mandate, which is to deliver sustainable services to all its citizens, it has to make decisions on behalf of its citizens (Republic of South Africa, 1996). The 21st century presents us with complex challenges that often demand difficult and complex decisions to be taken. Cilliers (2005a: 1–4) states that we cannot avoid making decisions and we have to take responsibility for our decisions, even if we are not able to foresee the implications of our decisions in advance. Ethical decision-making, which provides us with guidelines and rules on managing and making decisions within complex environments, is thus required (Loubser, 2013: 1–13) .

Due to the urgency of the current situation, and rate at which organisations are faced with challenges and problems in the 21st century, a culture of urgency and speed when dealing with challenges has emerged. Cilliers (2005c: 1–10) cautions against the "fastness" with which organisations respond to a problem, and explains the need for a "slower" response when dealing with complex problems. Cilliers (2005c: 1–10) further explains that this slowness would allow organisations adequate time to reflect and assess problems in a holistic manner, which would then allow the most appropriate measures to be taken in order to address these challenges.

Cilliers (2001: 135-147) further states that “the individual and collective values of members of the system cannot be separated from their functional roles”, implying that people’s beliefs and values form part of the way in which they make decisions and execute their functions. It is imperative that a municipality enforces its code of conduct to ensure that ethical decision-making is carried out, and that sufficient time is granted to allow for reflection before making decisions.

South African municipalities’ role through a complex systems theory lens

South Africa has a three tiered governance structure; namely national government that sets policy framework in place, provincial government that further drives and supports national policy framework and municipalities, that are defined as the implementing leg of this structure (Republic of South Africa, 1996). This governance structure not only impacts and influences its surroundings, but is itself influenced by and impacted on by its surrounding (Rotmans & Loorbach, 2009). There is a constant and evolving interaction between each structure, which is itself impacted by external and internal factors.

This definition supports Cillier’s (2004: 1–4) description of complex adaptive system, which he defines as being an open system which interact with its environment. The interactions between each element is non-linear and there are feedback loops with each interaction, which can be positive and negative (Morin & Kelly, 1977: 1–17; Richardson, Cilliers & Lissack, 2007: 532–537). Figure 2.6 is a graphical illustration representing the openness of such a system, as well as the non-linear interaction of the various elements. This graphical illustration is by no means exhaustive or complete, but serves merely as an illustration to represent the openness and connectedness of the various elements in a system, as defined by Cilliers (2004: 1–4) and Morin (1977: 1–17).

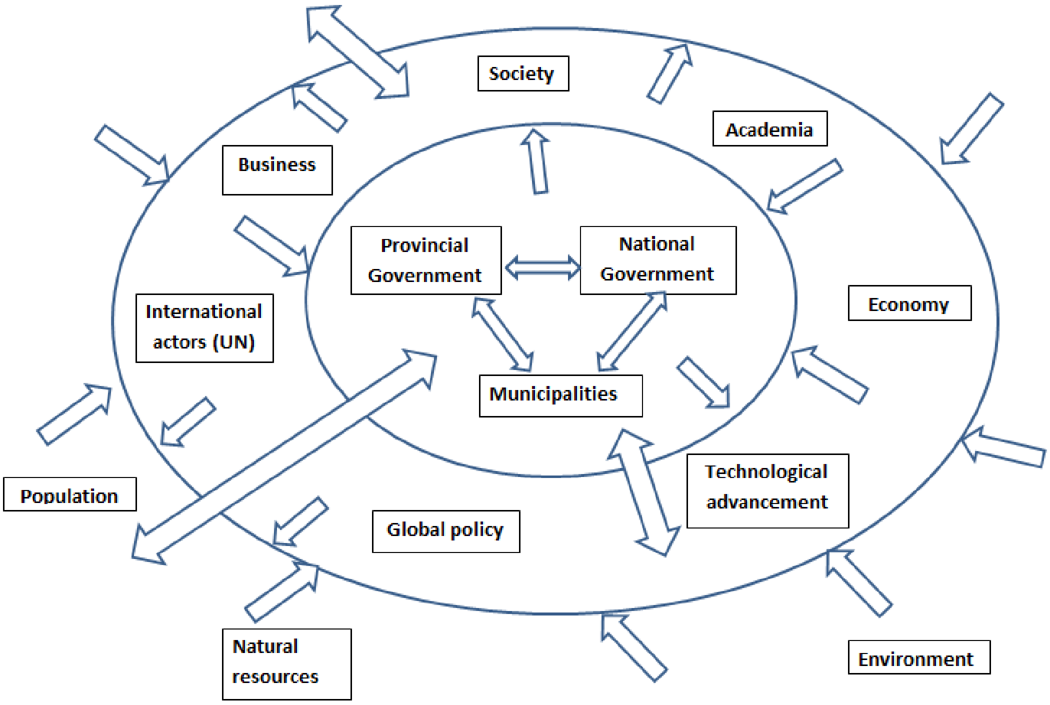

Figure 2.6: Graphical illustration of influences within and between systems

Source: Tshehla (2014)

A municipality is governed by the Constitution of South Africa (1996) and Municipal Structures Act (1998), and the role of the municipality is clearly defined in both, stating that a municipality must deliver sustainable services to all its citizens while supporting economic and social growth, without harming the environment (Republic of South Africa, 1996). These laws are further elaborated on in section 2.6. Complexity theory and systems thinking is best suited in examining the role of South African municipalities, which will aid in answering the current research problem. In order for a municipality to deliver sustainable services to all without harming the environment, while supporting social an economic growth, requires an understanding on how these different systems interact and impact one another. Complexity theory and systems thinking allows one to understand the dynamic between these variables (Senge & Sterman, 1992).

This research study specifically investigates the internal relationships within a municipality when implementing energy efficiency projects, as well as the manner in which the role of National Government has affected the implementation of energy efficiency programmes within the City of Cape Town's internal operations. The application of complexity theory and systems thinking assisted in analysing the relationships among the various City departments, with regards to the City's internal energy efficiency programme, and enabled the author to develop the most appropriate business plan to ensure funds beyond the guaranteed funding period.

2.6 South Africa's policy framework to support and develop energy efficiency

This section aims to give a broad overview of the energy policy framework with a specific focus on policy for supporting energy efficiency in South Africa. Reviewing the energy policy allows the author to highlight the positive factors in the current supporting framework, which enables municipalities to implement energy efficiency, as well as some of the gaps in the energy efficiency policy framework pertaining to municipalities. Reviewing the energy policy framework allowed the author to reflect on the energy efficiency programmes of the City of Cape Town which provided insights on the potential role which municipalities can play to support existing energy efficiency policy.

Overview of electricity policy framework in South Africa

Electricity generation in South Africa has historically been built around the country's abundance of coal reserves. Until recently, electricity prices in South Africa have been among the lowest in the world, with the average cost of electricity in 2008 being a mere R0.25c/kWh (Edkins, Marquard & Winkler, 2010). The electricity shortage and rolling blackouts first experienced in 2008 marked the end of cheap electricity in South Africa. South Africans have since experienced a 208% overall price increase over eight years, with the 2015 electricity price at R0.77c/kWh (Cape Town, 2015b). These are unprecedented price increases marking the end of the cheap electricity prices South African have been enjoying in the past (Edkins *et al.*, 2010).

Electricity generated from the use of coal contributes up to 95% of the electricity generated in South Africa (Cape Town, 2015a).This has led to the country being ranked as the 12th largest carbon emitter globally (UNEP, 2012). South Africa's carbon emissions in 2007 were recorded at 415 Mt CO_2 equivalent, compared to global total carbon emissions recorded at 41 240 Mt CO_2 equivalent (Republic of

South Africa, 2007). The country contributed 1% of global carbon emissions, making it one of the largest carbon emitting countries globally (Republic of South Africa, 2007).

The period from 1984 to 2010 was marked by critical political change in South Africa, which has impacted the electricity sector. The late 1980s saw the electricity sector and its policy under review through the de Villiers Commission of enquiry, with the aim of reforming the sector's energy policy and governance (Brent, Heun, Swilling, Meyer, Fluri, *et al.*, 2010: 1–11). The development of the White Paper on Energy Policy in 1986 saw the first attempts at diversifying the country's energy mix in order to secure future energy supply (Eberhard, 1994, bk. 215–253). The White Paper was gazetted in 1998, 12 years after the first developments of the policy (Brent *et al.*, 2010: 1–11). Figure 2.7 represents a brief historical timeline and overview of the key events which led to the development of the White Paper on the electricity sector of South Africa (Electricity Governance Initiative of South Africa, 2010; Bekker, Eberhard, Gaunt & Marquard, 2012: 3125–3137) .

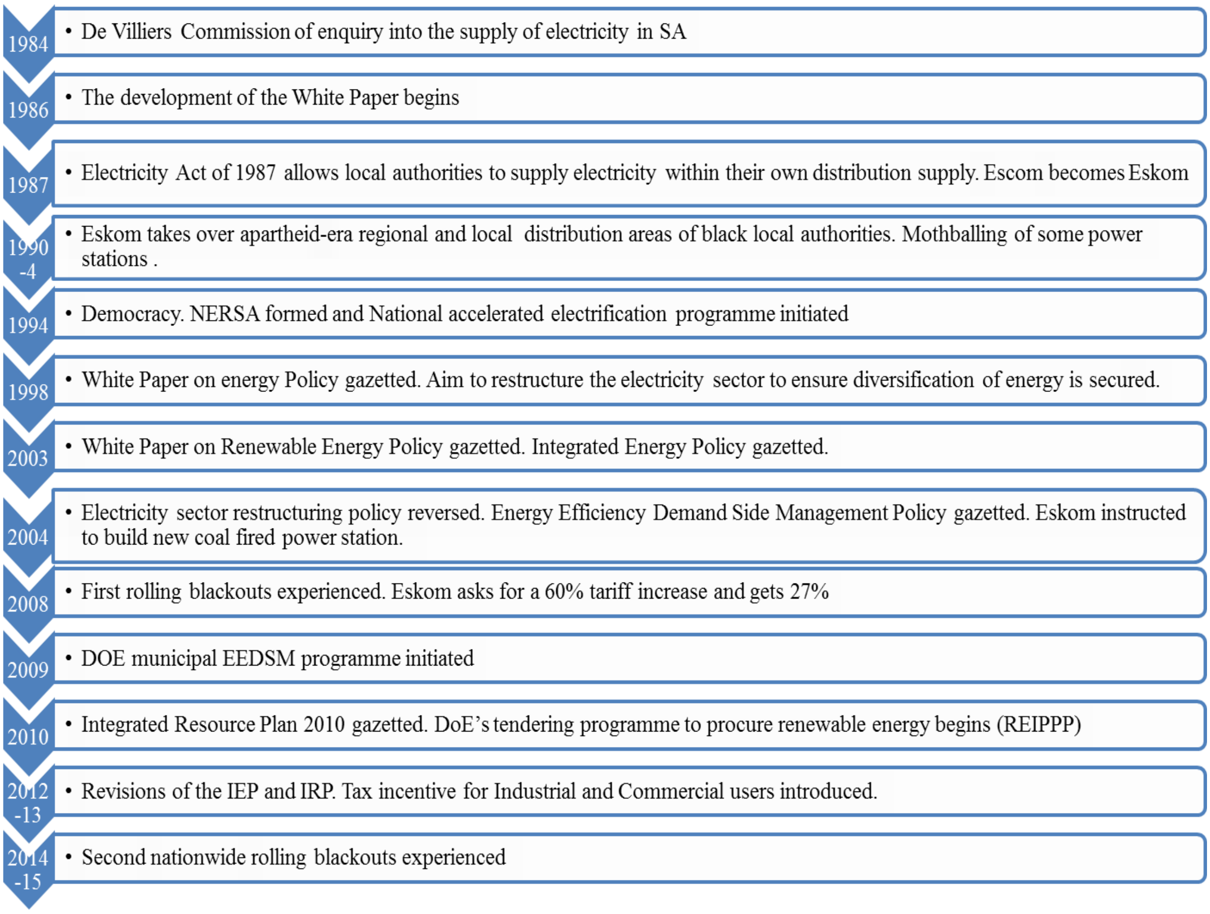

Figure 2.7: Illustration of key events in electricity sector of South Africa

Source: EGI, 2010; Republic of South Africa, 2013b; Cape Town, 2015b

It is important to note that policy development is a long and arduous process, but that the foundation and premise of the policy are the most critical aspects to consider. South Africa has a well-structured enabling policy framework that strives to promote both renewable energy and energy efficiency, as illustrated in Figure 2.8 (Brent *et al.*, 2010: 1–11). Policy is but a necessary first step in the process. Implementation has been slow, with a number of setbacks, including but not limited to, policy gaps and poor linkages between subsequent policies developed to further support the objectives of the Constitution. Above all, as stated by Brent *et al*. (2010: 1–11) each of the three tiers of government "works independently with very poor inter-governmental co-ordination and collaboration" (; Bekker *et al.*, 2012: 3125–3137).

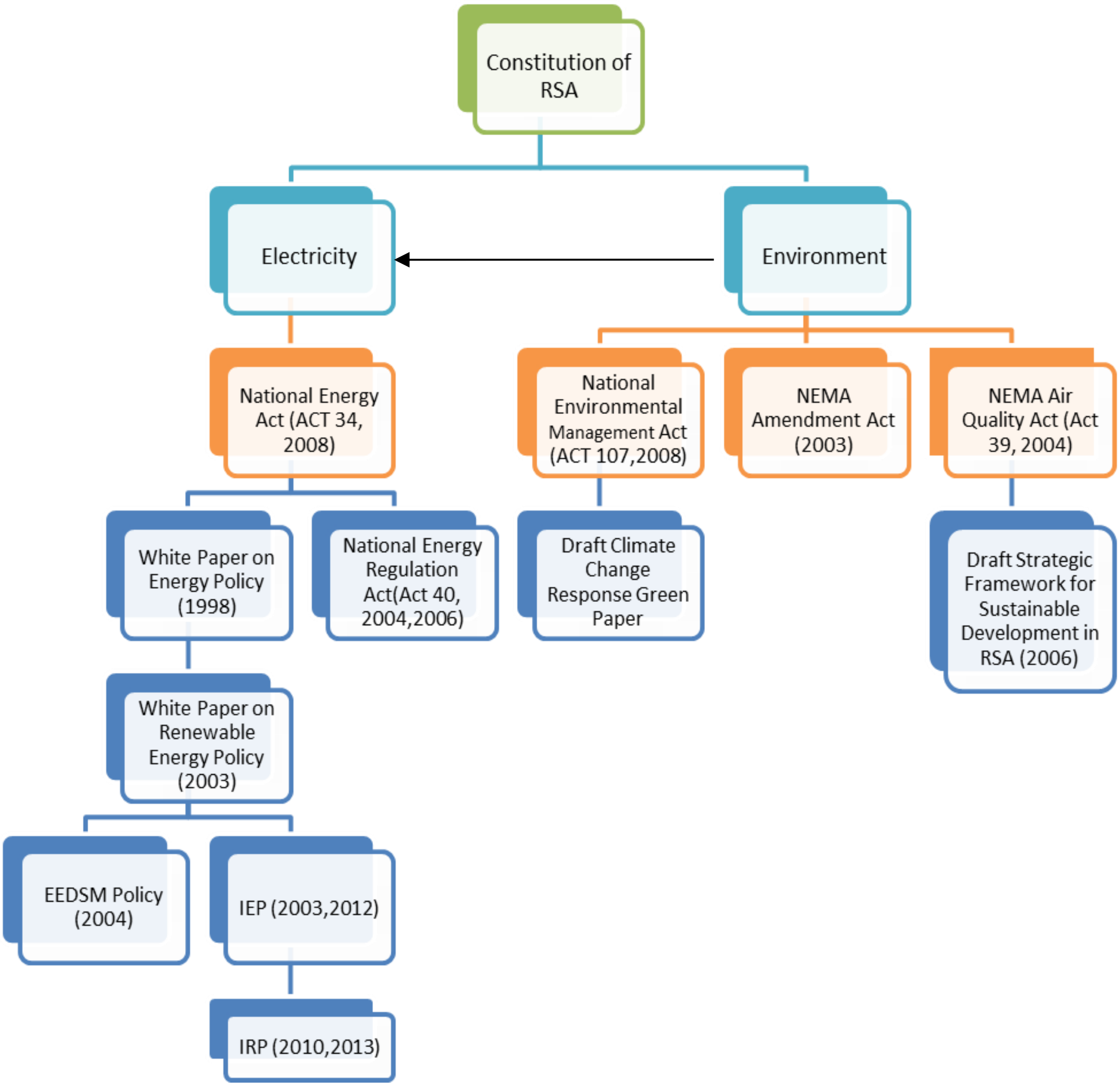

Figure 2.8: Diagrammatic illustration of Republic of South Africa electricity and environment policy

Source: Republic of South Africa (2003, 2013b)

It is important to revisit the above policy framework, in order to highlight the role of municipalities. This will enable them to assist national government in realising its aims within the various energy policies developed. Figure 2.8 is a mere illustration that maps out the various policies developed. This enables the author to draw linkages and highlight potential gaps, which could act as barriers to implementing energy efficiency from a municipal perspective.

The Constitution forms the foundation upon which all laws and acts of the country are developed (Republic of South Africa, 1996). Section 24 of the Constitution, known as

The Bill of Rights, states: *"that everyone has the right to an environment that is not harmful to their health or well-being and to have the environment protected, for the benefit of future generations, through reasonable legislative and other measures that; a) prevent pollution and ecological degradation, b) promote conservation and c) secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development"* (Republic of South Africa, 1996).

The Constitution therefore allows further policies to be developed in order to achieve the stated aims of the Constitution. Figure 2.8 illustrates the linkage between the environmental policy such as NEMA, which supports the development of sustainable electricity policy, and the Constitution. The National Energy Act 34 of 2008b is informed and guided by the principles of the Constitution and makes provisions in order to ensure that effective and integrated energy planning can occur. Municipalities play an integral role in contributing to the development of the country's energy planning process. The process must make provision to get input from the municipalities (Republic of South Africa, 2008b).

The White Paper on Energy echoes Section 24 of the Constitution, which sees economic development, securing diversity of supply of energy and managing energy related environment health impacts, as key objectives (Republic of South Africa, 2003). The White Paper does not explicitly define the role of municipalities, but does recognise that the South African Government has a three- tiered governance structure and therefore implies that all three tiers of Government must promote and adopt the principles of the policy (Republic of South Africa, 2003).

Policy framework in South Africa supporting energy efficiency

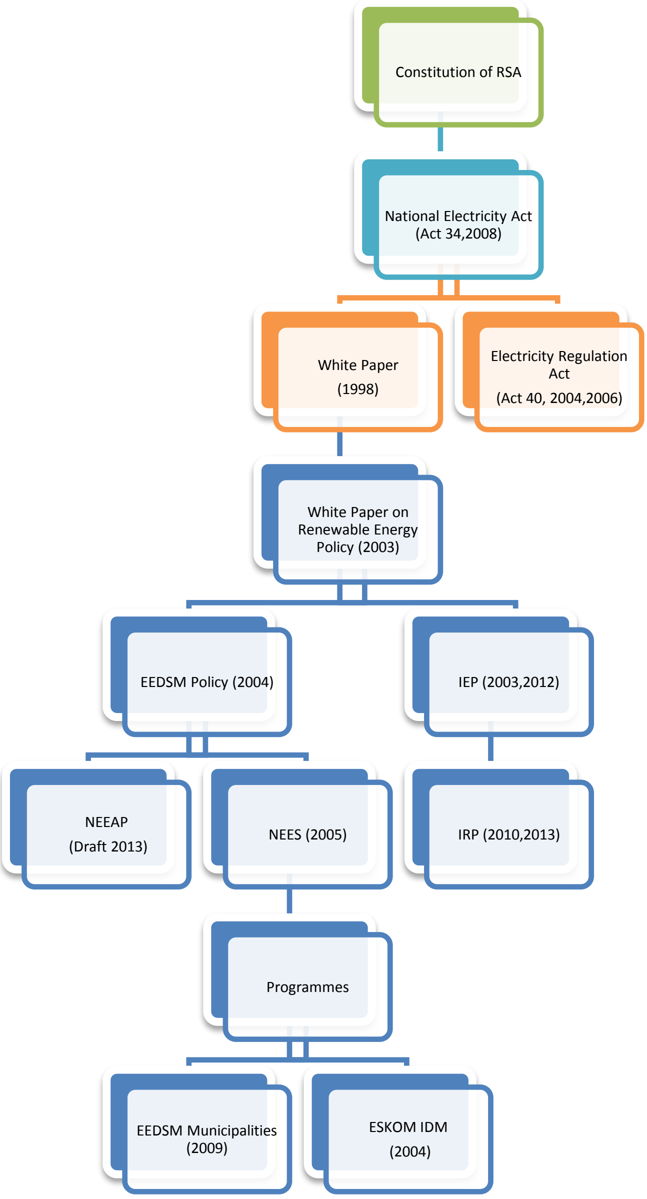

Figure 2.9: Diagrammatic representation of energy efficiency policy framework in RSA

Source: Republic of South Africa (1996, 2003, 2004)

South Africa's Constitution is one of the very few constitutions internationally, which recognises and addresses the importance of its environment (Hattingh, 2001: 1–30). Figure 2.9 illustrates the energy efficiency policy framework of South Africa. This section aims at understanding the policy developed in South Africa to implement energy efficiency, and examines the reason why, since 2008 South Africa has still not implemented the simplest energy efficiency strategies (Sebitosi, 2008).

The Energy Efficiency Demand Side Policy forms the core policy for all other policies and strategies relating to energy efficiency. The primary objective of the Energy Efficiency Demand Side Management policy is to enable the National Energy Regulator to develop a grant subsidy in order to assist Eskom in implementing energy efficiency programmes. The Energy Efficiency Demand Side Management policy does not focus on the role that municipalities can play in this process, but it does point out that certain municipalities have been implementing demand side management measures, such as load management, in order to manage peak demand. The Energy Efficiency Demand Side Management programme mentions the use of Energy Services Companies and the need for monitoring and verification of all Energy Efficiency Demand Side Management programmes implemented. This policy has ensured that South Africa could develop the Energy Services Companies and Monitoring and Verification sector, through Eskom’s expansive integrated demand management programme, from 2004 up until 2012 (National Electricity Regulator, 2004).

The need for a strategy was developed under the National Energy Efficiency Strategy (Republic of South Africa, 2009). National Energy Efficiency Strategy defines roles and sets targets for various sectors, to achieve energy efficiency. They have also set an overall target of 12% to be achieved by 2015, as illustrated by Table 2.3. The Challenge with the National Energy Efficiency Strategy is that it once again places the responsibility of implementation on the Department of Energy (DoE), Eskom and the Department of public works for government buildings, whereas the role of municipalities remains limited. Another key challenge within the strategy is that it does not focus on an overall monitoring and reporting programme, or detail who will have the responsibility of monitoring the process. (Republic of South Africa, 2014). This section illustrates the lack of cohesion amongst the various policies developed. The intention to develop a supportive policy framework to implement energy efficiency is there, but the roles and responsibilities of the implementing actors are not clearly defined (Sebitosi, 2008).

Table 2.3: Sector target set for energy efficiency

Sector	Industry	Mining	Power Generation	Commercial & Public Buildings	RResidential	Transport
Target	energy efficiency improvement of 15% by 2015	A energy efficiency improvement of 15% by 2015	energy efficiency improvement of 15% by 2015 measured by energy consumption of equipment, excluding the thermodynamic cycle	energy efficiency improvement of 15% by 2015	improvement in energy efficiency per capita of 10% by 2015	energy efficiency improvement of 10% by 2015

Source: Republic of South Africa (2009)

The rolling blackouts experienced in 2008 propelled the South African government to initiate and action a number of key programmes, such as the Municipal Energy Efficiency Demand Side Management programme. This programme was implemented and managed by the Department of Energy in 2009, and focuses on achieving energy efficiency within municipal infrastructure (RSA, 2009). The programme focuses primarily on upgrading municipal public lighting infrastructure with efficient technology (RSA, 2009). The municipal Energy Efficiency Demand Side Management programme has since evolved from focusing purely on public lighting to include: smart metering, capacity building, public awareness, energy efficiency in buildings but limited to lighting and sensors, energy efficiency in street, traffic lights, and waste water treatment facilities (RSA, 2009). A key challenge within the programme is that monitoring and verification was previously a function of the municipalities and that no holistic monitoring or verification of the overall programme was conducted (Department of Basic Education, 2014). Allocations to accessing this grant remain politically driven and communication between the Department of Energy and the municipalities remain challenging and uncoordinated (Brent *et al.*, 2010: 1–11). Amidst the overall programme and administrative challenges of the Energy Efficiency Demand Side Management programme, municipalities have been granted the opportunity to strategically set in place an organisational process and system to implement energy efficiency and build capacity in the field of energy efficiency (RSA, 2009).

2.7 The role of municipalities in implementing energy efficiency, South African context

Section 152 (1b) the Constitution states the following: "[t]he objects of local government are to ensure the provision of services to communities in a sustainable manner" (Republic of South Africa, 1996: 152 (b)). Legislation under the "*Local Government: Municipal Structures Act 117 of 1998"* (Republic of South Africa, 1999) further expands on the services which local government must deliver , stated as follows: " sustainable, effective and efficient municipal services, promote[ing] social and economic development, encourage[ing] a safe and healthy environment" (Republic of South Africa, 1999).

Legislation clearly makes provision for municipalities to implement sustainable services, as illustrated by the legislative clause above. The South African Cities Network (2014) published a report which reviewed the legislation and literature pertaining to energy efficiency and renewable energy at the local government level. The study raises the concern that interpretation of legislation at the municipal level has considerable impact on the manner in which services are ultimately designed and implemented (South African Cities Network, 2014). This interpretation of the law, if taken very strictly, can be constricting and limiting from a progressive and innovate perspective (South African Cities Network, 2014). This supports Cillier's (2001: 135-147) statement that "*the individual and collective values of members of the system cannot be separated from their functional roles*". This clearly illustrates the complexity of municipal officials taking a conservative perspective of the law, and thereby slowing down the implementation of any progress or innovative programme. The following section examines case studies in which municipalities have decided to take a much more progressive interpretation of the law and develop their own roles pertaining to energy efficiency and sustainable development within the municipal context.

2.8 Examples of South African municipalities implementing energy efficiency by defining their roles within the given policy framework

South Africa has 273 municipalities of which there are 7 metro's (Cape Town, 2015a). The South African Cities network (2014) study revealed that all the large metropoles in South Africa have been focusing heavily on electricity efficiency within their municipal infrastructure, since the inception of the Department of Energy's municipal Energy Efficiency Demand Side Management programme (South African Cities Network, 2014). Municipalities such as Ekhuruleni, Tshwane, eThekwini and the City of Cape Town have been progressive in the field of energy efficiency. The municipalities have developed their own strategies, targets and policies to implement energy efficiency within their own operations (Ekurhuleni, 2010b; South African Cities Network, 2014).

The City of Cape Town has an energy and climate change strategy (2006), energy and climate action plan (2011), and a dedicated Energy and Climate Change Unit which drives energy efficiency programmes within the City of Cape Town (City of Cape Town, 2006, 2011). Chapter 3 elaborates on these programmes. The City of Cape Town is the only municipality in South Africa that has implemented performance savings guaranteed contracts within its building energy efficiency programmes to date (South African Local Government Association, 2014). The South African Local Government Association (2014) developed a case study report documenting the City of Cape Town's approach and their reason for choosing to implement such a complicated contracting method. The key lessons learnt from the implementation of a performance guaranteed savings contract, has been that it has allowed the City of Cape Town to develop its internal capacity to manage and monitor performance guarantee savings contracts. It has further proven that legislation is not a barrier, rather that the municipal supply chain management policy (2013), guided by the Municipal Structures Act (1999), supports innovative contracting methods.

eThekwini municipality is also known for its progressive energy and climate change programmes, as the municipality has a dedicated energy unit which focuses on energy efficiency within the municipality (eThekwini, 2012). eThekwini municipality's policy acts as a guide to internal departments on means by which they can become energy efficient through procuring energy efficient technologies. The implementation of the eThekwini Internal Energy Management Policy seems like a good blueprint for other municipalities to operationalise energy efficiency within their internal operations.

However, since the adoption of this policy, eThekwini municipality has struggled to get other departments to adopt this policy as well. Furthermore, understanding how to implement energy efficiency programmes, as well finding the correct institutional structure to drive and implement this policy, seems to be a major stumbling block (eThekwini, 2012).

Ekurhuleni municipality in Gauteng developed an energy efficiency strategy in 2010 (Ekurhuleni, 2010a) and undertook a comprehensive study which included reviewing international best practice on energy and climate change strategies within the municipal sphere. The review included examining the City of Cape Town's Energy and Climate Change Strategy (City of Cape Town, 2006). On conclusion of the review, they implemented a combination of the City of Cape Town's strategy, as well as the strategies of other international cities.

The City of Johannesburg is known to be the first municipality to have applied to the National Energy Regulator for a Demand Side Management levy, through their electricity distribution company, City Power.The environmental levy for R0.02/kWh, which is applicable to all electricity users who use more than 500 kWh per month (Ekurhuleni, 2010a). The approval of this application by the South African National Energy Regulator has set a precedent for municipalities to consider adopting "ring fence" funds, which are dedicated to energy efficiency within the municipal infrastructure. Ekurhuleni municipality is the only other municipality in South Africa to have followed the City of Johannesburg's Demand Side Levy (Ekurhuleni, 2010b). Since the approval and implementation of its environmental levy on electricity consumption, Ekurhuleni municipality has been implementing year on year energy efficiency programmes, proving to be another successful model for making energy efficiency implementation within municipal operations sustainable (Ekurhuleni, 2010b).

The City of Tshwane has a sustainable energy unit and has developed a Green Buildings Policy (City of Tshwane, 2009). The Green Buildings Policy (2009) focuses on improving the performance within the built environment by reducing environmental impacts and improving quality of life within the city's built environment. This policy applies to all new buildings within the City of Tshwane and uses three policy instruments to enforce this policy namely, through the development of a Green building development by-law, Green Building Development Policy and a Green Building development Incentive Scheme (City of Tshwane, 2009). The Incentive Scheme allows applicants of new building plans to be fast tracked should they be compliant, allows for a reduced application fee and awards formal performance recognition certification. (City of Tshwane, 2009). The success of this policy is unknown at this time, as no formal studies have been conducted to assess the impact of this policy. The implementation of this Policy proves that municipalities can play a strong role in implementing sustainable development measures and, in return, support the climate change goals of national government.

The case studies reviewed are by no means exhaustive, but illustrate that policy is not an inhibiting factor for energy efficiency in municipalities. This supports the intent of this research to examine some of the progressive measures of implementing sustainable energy efficiency programmes that are not reliant solely upon the National Energy Efficiency Demand Side Management grant fund.

2.9 Summary

Policy remains a key driver for creating an enabling framework to implement energy efficiency. The focus on most of the energy efficiency literature has been a top down approach focusing on National policy (World Energy Council, 2013; Gómez-calvet *et al.*, 2014). An important aspect which has emerged from the literature, is that a well defined policy framework does not necessarily lend itself to naturally allow for implementation (Reddy, 2013: 403–416). The example of the European Union Energy Efficiency Directive (2012) illustrates that a well considered and intragovenmental policy, with linkages and a co-ordinated approach, is required.

In the municipal context, political will and support from the senior executive management, remains a key factor to propelling municipalities to implement and develop systems and further drive energy efficiency. The European Union (2012) initiated the Covenant of Mayors, which enables support and commitment from the top down within local authorities in implementing energy efficiency measures (Christoforidis, Chatzisavvas & Lazarou, 2013).

There is a huge disconnect in the energy efficiency policy in South Africa. Follow-up policies and programmes have been established, yet government cannot asses the impact of the overall Energy Efficiency Demand Side Management programmes implemented to date (Brent *et al.*, 2010: 1–11). Another key challenge is that Eskom has been tasked with driving energy efficiency, yet this runs contrary to the state-owned utility’s objective. Its primary focus as a generator of electricity is to increase sales.

3 Methodology and Research design

This chapter focuses on describing the research design and the methods followed in gathering and analysing the necessary data in order to answer the research questions. A mixture of qualitative and quantitative methods has been used in this research study. The research approach for each research question is described in detail, explaining why specific instruments were used in order to gather and analyse data.

3.1 Research design

Bryman & Bell (2011) describes the research design process as follows: "*research design provides a framework for the collection and analysis of data*". Miller & Salkind (2002) state that there are key factors to consider when constructing your research design. The key factors considered during the research design process for this study were as follow:

a) The type of data which exists, namely: secondary quantitative data;
b) The City of Cape Town is a government entity and therefore a pure quantitative method will not provide the necessary insight into the full dimension and depth of the organisation being studied; and
c) The data gathering methods to be considered for the qualitative data being collected.

Bryman & Bell (2011) further describe five research design methods, namely: a) experimental design which focuses on laboratory and field experiments to gather data; b) cross-setional design which uses methods such as participant observation, journals, and so forth; c) longitudinal design which is used to map the changes an organisation experiences, d) case study design which focuses on a particular aspect which is then analysed in depth; and e) comparative design, which focuses on comparing two or more cases and drawing comparisons between them (Bryman & Bell, 2011).

While taking these factors into consideration, and understanding the different research design methods, we use Figure 3.1 to illustrate the research design developed for this study. Figure 3.1 further demonstrates the process followed, starting with an in depth literature review to conceptualise the problem and pair the research questions with desired objectives.

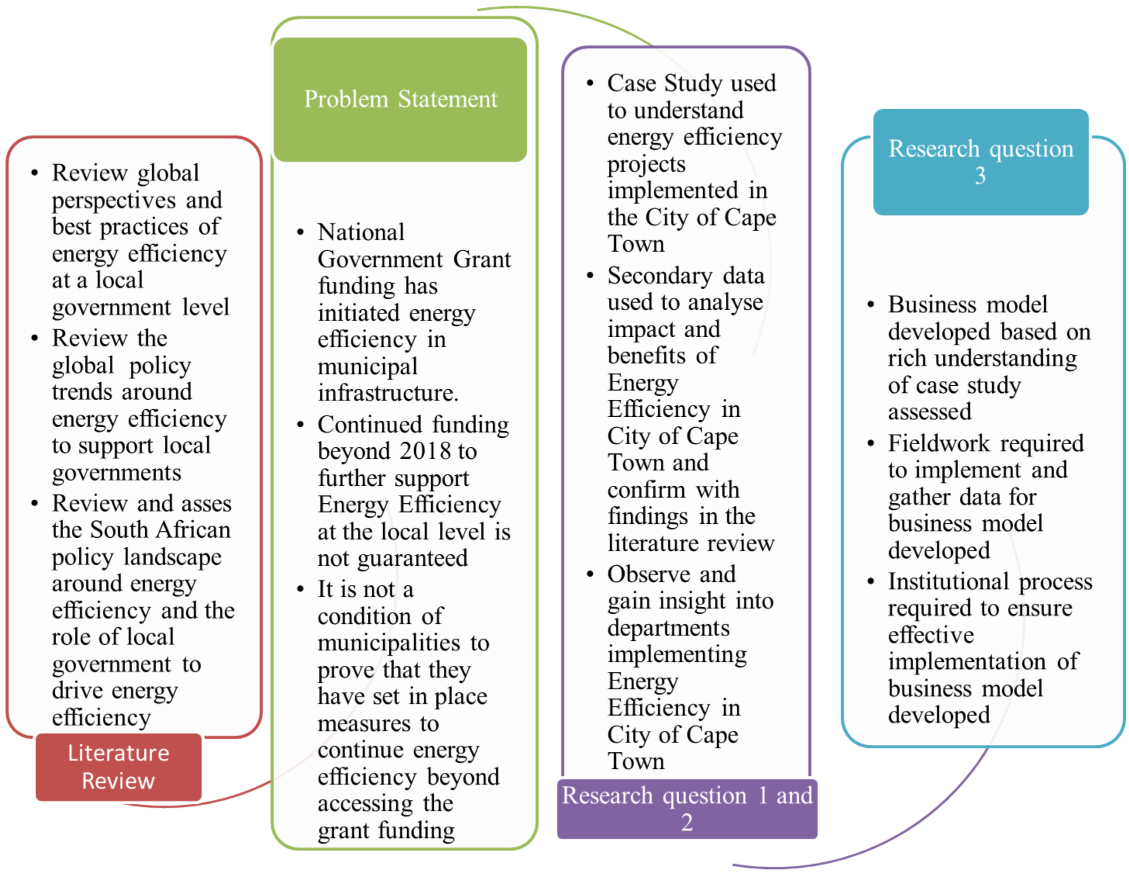

Figure 3.1: Illustration of research design

Research methodology

During the research design process it was evident that both qualitative and quantitative data would be required (Harwell, 2011). The methodology best suited for this research was that of mixed methods. According to Creswell (2003) and Bryman & Bell (2011) the strengths of both methods are drawn on and therefore lend themselves to a holistic approach. Bryman & Bell (2011) discuss a number of approaches that qualify as mixed methods. One of the approaches discussed is the triangulation method, which allows the researcher to validate either the quantitative or qualitative data.

A comprehensive body of literature was reviewed in order to ensure that the appropriate theories were selected and applied to the case study. The literature review also entailed the review of international best practice, as implemented by other cities. This was then used to highlight best practice as implemented by the City of Cape

Town. The case study allowed insight to be gained from each department implementing energy efficiency within the City of Cape Town.

The author was actively involved in driving the City of Cape Town's internal operations energy efficiency programmes. Through keeping detailed notes, attending meetings and hosting a number of workshops with a variety of departments on specific energy efficiency projects, a rich and deep insight was gained from all players. This methodology is described as participant observation (Rugg & Petre, 2007). The reflective aspect of the study and participant observation allowed the author to confirm the best practice implemented, as highlighted by the literature review of global cities currently implementing energy efficiency (Rugg & Petre, 2007). Using the case study, literature review and active and direct participant observation allowed the application of a triangulation methodology to be applied to research question 2 and 3 (Bellamy & Perri, 2012).

3.2 Research approach

This section describes the tools and instruments used to collect and analyse data for each of the research questions. A case study was used which allowed for both qualitative and quantitative methods of data collection. Various instruments for gathering and analysing the data were specific to each research question. The following section therefore describes the research methodology, data collection methods and analysis for each research question.

Research Question 1: What is the extent to which the current energy efficiency programmes have been implemented in the City of Cape Town's internal operations?

a) Case Study

A case study was used as it allowed for multiple research methods to be utilised. The case study entailed assessing the entire energy efficiency programme in the City of Cape Town's internal operation (Bellamy & Perri, 2012). The City of Cape Town's Energy & Climate Change Unit provided the secondary quantitative data on the entire energy efficiency programme, which was used in this research. The results of the case study, as discussed in detail in chapter 4, were developed on sourcing project data which entailed the electricity consumption and savings in kWh, the kind of technologies or interventions implemented, the departments involved, time frames and cost savings. This data was sourced from the Energy and Climate Change Unit which collects the electricity consumption data of various sectors, which is then used to compile a State of Energy Report every four years. This State of Energy Report is based on electricity and transport fuel consumption. The Energy and Climate Change Unit collects information internally from the City of Cape Town department's electricity consumption, as well as energy efficiency projects implemented for the year 2015. This data was made available through the State of Energy Report for 2015 (Cape Town, 2015a).

The high level overview of Cape Town's energy consumption data, displayed in Chapter 4, was sourced from the State of Energy Report for 2015. The Energy and Climate Change Unit has a Microsoft Excel spreadsheet which records the investment cost of the project, electricity consumption in kWh per month, the electricity savings in kWh, the financial savings in Rands, project implementation date, location and technology interventions implemented. This spreadsheet has data for energy efficiency projects starting in 2003, and is updated annually by the Energy and Climate Change Unit. This Excel spreadsheet was made available to the author. This quantitative secondary data obtained from the Energy and Climate Change Unit was put into a Microsoft Excel spreadsheet, which was used to develop graphs and tables used to analyse and discuss the findings in the case study. These results are presented and discussed in Chapter 5. The development of graphs from the data assisted with identifying trends and providing insight into the reason why specific departments were more progressive in adopting energy efficiency technologies, while other departments lag behind.

The case study focuses on the Electricity Services department, Traffic Signal department and Specialised Technical Services department that worked closely with the Energy and Climate Change Unit in implementing energy efficiency projects. A set of criteria was developed to determine the level to which a department has adopted or embedded the new energy efficient technology in their business processes. These criteria are illustrated in Figure 3.1. This set of criteria was developed in order to establish the level of change that has occurred to implement energy efficiency within a department. This set of criteria was applied to all three departments namely Electricity Services, Traffic Signal Department and Specialised Technical Services. The Electrity Services department is responsible for managing the distribution network and all street lights within the City of Cape Town's municipal boundary. The Traffic Signal department is responsible for all the traffic lights. Specialised Technical Services department is responsible for managing all the City of Cape Town's large corporate administrative buildings. The criteria assisted in determining whether the department had changed its 'business as usual' to a more energy efficient path as well as allowing the author to compare the performance and progress of the three different departments.

City of Cape Town departments that use frequent consumable items such as soap, toilet paper and light bulbs, are required to keep a certain amount in the City of Cape Town's stores. These are known as a stock item and get used on a regular basis to maintain and support the City of Cape Town's internal operations. All equipment used for street lighting, traffic lighting and building lighting are stored in the City of Cape Town stores. Departments are not allowed to go and procure these items externally. A department would need to prove that a specific item is not stocked in the City of Cape Town's stores, before being granted permission to source it externally through a tender process.

The City of Cape Town's store stock items becomes a crucial means of assessing if a department has truly changed its operations by only stocking the energy efficient lighting items. A set of criteria was developed and a weight was assigned to each question. The questions developed resulted in a 'yes' or 'no' answer. If the answer to the question was yes, then the full weighted score was allocated. If the answer to the question was no, then a zero weight was allocated. Table 3.1 illustrates the set of questions developed and the weight assigned to each question. The weight assigned to each question indicates the importance of the question and the associated result. Table 3.1 allows the author to assess the department's performance. This set of criteria has been applied to all three departments and the results are shown and discussed in Chapter 5.

Table 3.1: Illustration of criteria questions developed

Criteria			Department score		
			Electricity Services Department	**Traffic Signal Department**	**Specialised Technical Services Department**
1. Have the store stock items been upgraded to stock the energy efficient product item? (How energy efficient is this product item?)	Comment	Yes/ No			
	Weight	20			
2. Has the entire old product item (in-efficient) been removed from the stores?	Comment	Yes/ No			
	Weight	40			
3. Has the technology in the store stock items been changed to be completely energy efficient?	Comment	Yes/ No			
	Weight	25			
4.Has the department changed their business as usual approach to be more energy efficient?	Comment	Yes/ No			
	Weight	10			
5. Has the department's staff been trained to maintain the new technology?	Comment	Yes/ No			
	Weight	5			
Total		**100**			

b) Participative observation

Rugg & Petre (2007) describe participative observation as a useful and insightful way to gather qualitative data though participation in the research study. The author managed as well as engaged with and advised the various departments in the City of Cape Town's internal operations on energy efficiency. The author could therefore, through engagement with various departments, gather data and gain insight into the projects and each department's attitude towards implementing energy efficiency. This method was used to gain a deeper insight and confirm the general attitude of key departments and role players involved in the City of Cape Town's energy efficiency programme within its internal operations. Responses, interactions with departments and personal observations were recorded in the form of meeting and workshop minutes, field notes and reports.

c) Literature Review

An in-depth literature review was conducted, providing evidence and support and highlighting key trends and behaviours as identified in similar case studies globally and in other local municipalities. The literature review was used to confirm and support the findings from the case study and the participative and direct observation methods applied to answer research question 1. This allowed for a triangulation method to be applied in order to answer research question 1.

By using a combination of the case study method, participative observation, and literature review methodologies, the author was able to answer research question 1 in a holistic manner. The case study methodology has the limitation of not being generalised, due to the specific real life situation being analysed. The specific in-depth focus of the study allows for richness and depth in the case study, but findings cannot be generalised. The literature review and participative observation methodologies have been used to minimise the problem associated with case study methodology. The literature review assisted in identifying and supporting trends highlighted in the case study. Technology that is considered to be the easiest to implement, with regards to municipal internal energy efficiency operations, are street, traffic and building energy efficiency interventions. These interventions were discussed in depth in the case study presented in Chapter 4, as the initial areas of focus within the City of Cape Town's internal operations. The literature review and examples of global municipalities implementing energy efficiency within their own operations confirm that these interventions are the easiest for a municipality to implement. While attending national government municipal energy efficiency network meetings and international municipal energy efficiency network meetings, the author further confirmed some of the trends and findings highlighted in the case study, as presented in Chapter 4. Combining these methods serves to confirm and highlight the technical aspects that need to be considered in implementing energy efficiency within a municipality's own operations.

Research Question 2: What are the benefits and challenges for implementing energy efficiency programmes within the City of Cape Town's internal operations?

a) Case Study

Case study methodology was used to highlight the challenges and benefits experienced by each of the departments that implemented energy efficiency projects within the City of Cape Town's internal operations. The case study provided valuable insight from each department that implemented energy efficiency projects. This assisted in identifying common challenges and possible benefits, which other City of Cape Town departments might also experience.

b) Participative and Direct observation

Being directly involved in, and working closely with departments, in implementing energy efficiency within the City of Cape Town's own operations, has allowed the author to gain a deeper understanding of the challenges and opportunities experienced on each of the projects implemented (Rugg & Petre, 2007). Being the City of Cape Town's representative allowed the author to participate in provincial, national, and international workshops, allowing the author to interact with a wider audience and gain deeper insight around driving energy efficiency within government infrastructure. A workshop was jointly hosted by the South African Local Government Association and the City of Cape Town's Environmental Resource Management Department, aimed at assisting other Western Cape municipalities to access the national government energy efficiency grant funding. This workshop allowed the author to gain a deeper insight into the challenges and opportunities faced by smaller municipalities, and why they are interested in pursuing energy efficiency. These responses and personal observations were recorded in the form of fieldwork notes, reports and meeting minutes, which gave further insight into the topic addressed by the research question.

c) Literature Review

An in-depth literature review was conducted, providing evidence and lessons learnt from global and local municipalities. The literature review provided insight and highlighted current global key challenges and benefits for municipalities when implementing energy efficiency. The literature review was used to confirm the findings from the case study and participative and direct observation methods were applied to answer research question 2. This allowed for a triangulation method to be applied.

As previously stated, the case study methodology has the limitation that the findings cannot be generalised. Using a triangulation method, by combining the methods of literature review to present a global best practice, and examining challenges experienced by municipalities, supported the findings presented in the case study. The participant observation allows for direct and deep engagement with a set of actors on the research topic. The combination of these methods ensures that the findings presented are adequately supported by the data and literature review presented.

Research Question 3: What is the business model required to enable the implementation of energy efficiency programmes within the City of Cape Town's internal operations beyond the guaranteed funding period?

a) Case Study

Analysing the secondary data used in the case study allowed common challenges, gaps and benefits to be identified amongst the departments. The business model required an understanding of the current institutional and policy framework. A case study was used to develop the proposed business model. It is important to clarify that within the municipal context a business model is not a pure financial business case. It should rather be seen as a business process that requires the policy framework, organisational setting and departmental business plans to be developed. The policy and organisational setting framework presented in Chapter 4 is in the form of a case study. A review of the existing City of Cape Town policies relating to resource efficiency and efficient utilisation of assets was conducted. With the primary focus of illustrating where, within the organisational framework, the Internal Energy Management Protocol would be adopted. The Internal Energy Management Protocol was created by the Energy and Climate Change Unit with the main aim of guiding departments on ways of implementing energy efficiency within their own operations.

The business process developed in chapter 4 assisted in developing the business model, which can be applied to all other City of Cape Town departments wanting to implement energy efficiency. The generalizability of this business model will be dependent on the municipalities' organisational framework, however, the business process and the development of the Internal Energy Management Protocol framework presented in this study can be applied to all municipalities.

b) Literature review

Conducting an in-depth literature review allowed greater insight from a policy perspective. The literature review highlighted the fact that policy is required and that support and buy-in from the most senior level within any organisation is required in order to ensure sustainable implementation of energy efficiency. Understanding the complexity of the organisation and its institutional structures also assisted in ensuring a holistic approach was taken when developing the business model.

c) Fieldwork

In order to develop a business plan for a department, a full and comprehensive list of buildings was required, with the size of each building indicated. Electricity consumption data for each building was required. While developing the business plan, it was identified that the full list of buildings supplied by each department indicated that not all the buildings had electricity consumption data. This is because most of the facilities are not metered. Due to this data gap, fieldwork was conducted in order to gather the required data. The electricity consumption of a building can be theoretically determined by conducting an energy audit (Annunziata *et al.*, 2014). Energy audits for the selected departments forming part of the pilot were required in order to implement the business model. A sample size was determined for each department. This sample size then required a physical energy audit to be conducted for each building identified in the sample size. The floor size of each building was identified as another gap in the data. The City of Cape Town uses a software package called City map viewer, a Geographical Information System (GIS), which contains a measurement tool to calculate the floor size of the buildings. Over five hundred and eighty four buildings' floor size has been calculated using City map viewer. The floor size takes into account the height of the buildings. The total floor space is determined using City map viewer tool and then multiplying the number of floors the building has.

Over a period of six months, from June 2015 to December 2015, energy audits were conducted. The energy audit process entailed a physical walk-through of a building, where a count of all equipment with its specific rated power was done. The operating hours were established through interviews with the facility managers in order to determine equipment usage hours. This information was then used to determine the theoretical electricity consumption of the building (Annunziata *et al.*, 2014). The primary data collected from the energy audit and the floor size data for the sample size were used in a Microsoft Excel spreadsheet to determine the electricity consumption per annum for the department. The energy audit data also allowed for key energy intensive technologies to be identified. This allowed for prioritisation and targets for each department to be determined.

This section aims to explain the methodology developed to assist in creating these departmental business plans and establishing energy targets for various departments within the City of Cape Town. As previously explained, data is currently poorly collected in City of Cape Town buildings and facilities. In order to develop a business plan and establish energy targets for various departments, energy data is required. The Environmental Resource Management Department initiated the process of improving data collection with its Specialised Technical Services department since early 2007. Data for the Specialised Technical Services departments facilities is based on electricity consumption metered data and floor size data, which is known by the department. The Environmental Resource Management Department has a good understanding of the function and utilisation of Specialised Technical Services buildings and has years of experience with regards to energy efficiency projects within these administrative buildings. Project data on the energy efficiency interventions implemented and cost at these administrative buildings are well documented.

Figure 3.2 best illustrates the data required in order to develop an energy efficiency business plan and energy targets for a department. Consumption data, specifically electricity, can be obtained through the meter data or the utility bill, and this information is easily accessible on the City of Cape Town's SAP system. General building data was identified as one of the gaps in the data collection process. Departments were able to confirm the number of facilities they manage and give a description of the function and usage of the facilities. Information on equipment type, equipment usage and meter square data, however, is not collected by departments.

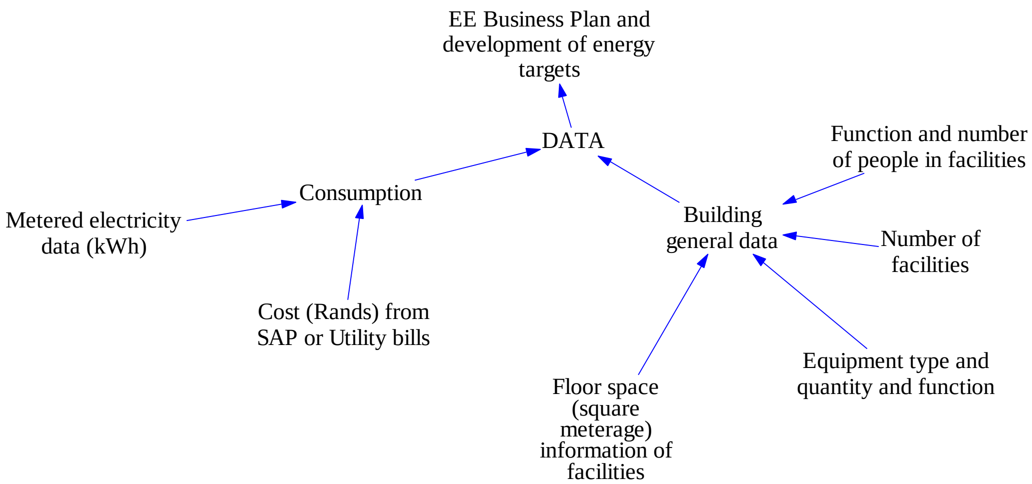

Figure 3.2: Graphical illustration of data required to develop energy efficiency business plan and energy targets for City of Cape Town departments

In order to bridge the data gaps identified, an energy audit was required, in order to determine the equipment type and usage within a specific building. City map viewer software, as utilised by the City of Cape Town, was used to determine the building's floor size. A representative sample size for each pilot department using the statistical sample size equation was established. The audit information highlighted the energy intensive consumption sectors per department. This information is presented and discussed in chapter 6. The energy audit information did not only highlight which equipment consumed the most electricity, but also assisted in ranking facilities based on which was the most energy intensive. This information was helpful in the development of the energy efficiency business plan and the development of an energy target for the department.

Table 3.2: Sports Recreation and Amenities: number of facilities and sample size established for energy audits conducted

Category of facility	Number of facilities	Number of smart meters	Total number of meters	Sample Size	Audits conducted
Sports Grounds	150	2	2	14	15
Community Centres	186	16	16	20	20
Multi-Purpose Centres	11	1	1	5	5
Swimming Pools	36	2	2	8	8
Stadiums	7	1	1	3	5
Bathhouses	12	5	5	5	5
Adventure centres	1	0	0	1	1
Resorts	13	0	0	2	5
Tidal Pools	19	0	0	0	0
Beaches	82	0	0	13	14
Public Toilets (With Electricity)	32	0	0	8	9
Public Toilets (Without Electricity)	33	0	0	0	0
Total	**582**	**27**	**27**	**79**	**87**

Table 3.2 provides an overview of the twelve categories of sports and recreational facilities, which form part of Sports Recreation and Amenities . The sample size only included facilities that used electricity. 87 facilities were audited. This sample size is 9% larger than the calculated and required sample size. Increasing the sample size assists in presenting a more representative sample of the entire potential data (Fox, Fox & Hunn, 2009). The following equation was used to determine the sample sizes of the department's buildings to be audited:

$$\boldsymbol{Sample\ Size \quad = \quad Z^2 \quad x \quad (p) \quad x \quad \frac{(1-p)/}{C^2}}$$

Where: Z= Z value (confidence level); P = percentage picking a choice, expressed as decimal; C= confidence interval, expressed as decimal

Sample calculation for Sports Ground sample size as illustrated in Table 3.2 :

$$Sample\ Size \quad = \quad (1.96)^2 \quad x \quad (0.5) \quad x \quad \frac{(1-0.5)/}{(-0.26192)^2} \quad = \quad 14$$

The floor size data for each category was used to establish an annual kWh/m^2/annum figure, which assisted in determining an annual electricity consumption kWh/annum figure for each facility category. From Table 3.3 it can be seen that the electricity consumption per annum from the energy audits, is higher than the electricity consumption per annum from the City of Cape Town's SAP system, which is based on electricity meter data. The energy audit's area of investigation had higher annual electricity consumption and this can be attributed to the operating hours estimated to determine the consumption.

Table 3.3: Summary of audit and m^2 data collected to determine annual kWh consumption for SRA facilities

Category of facility	Average kWh/ m^2/ annum (from audit)	Total floor size (m^2)/ category (determined with GIS tool)	Average kWh/annum (Based on m^2 data)	% Split from kWh/ annum	Average kWh/ annum (based on SAP data)	SAP Total kWh/ annum figure
Sports Grounds	55	114 287	6 288 890	30.1%	4 540 066	**15 097 007**
Community Centres	21	162 354	3 442 772	16.5%	2 485 401	
Multi-Purpose Centres	106	58904	739 593	3.5%	533 926	
Swimming Pools	36	20443	6 266 073	30.0%	4 523 594	
Stadiums	76	26757	2 040 807	9.8%	1 473 296	
Bathhouses	116	2075	241 659	1.2%	174 458	
Adventure centres	18	1187	21 927	0.1%	15 829	
Resorts	89	15586	1 388 669	6.6%	1 002 506	
Tidal Pools	N/A	N/A	-	0.0%	-	
Beaches	34	12403	420 614	2.0%	303 648	
Public Toilets (With Electricity)	16	3754	61 337	0.3%	44 280	
Public Toilets (Without Electricity)	N/A	N/A		0.0%	-	
Total		**417 750**	**20 912 343**	**100%**	**15 097 007**	

Sample calculation on Sports Ground facility:

$$\boldsymbol{Average\ \left(\frac{kWh}{annum}\right)(based\ on\ floor\ size\ data\ =\ 55\ \left(\frac{\frac{kWh}{m2}}{annum}\right)\ x\ \ 11\,4287\ \ m^2}$$

$$Average\ \left(\frac{kWh}{annum}\right)\ (based\ on\ floor\ size\ data) = 6\,288\,890\ (\frac{kWh}{annum})$$

$$\%\ Split\ from\ (\frac{kWh}{annum}) = \frac{Average\ (\frac{kWh}{annum})}{Total\ (\frac{kWh}{annum})}$$

$$\%\ Split\ from\ (\frac{kWh}{annum}) = \left(\frac{6\,288\,890}{20\,912\,343}\right)\ x\ \ 100\ = 30.1\%$$

In order to calculate the Average kWh/annum (based on SAP data) the following sample calculation illustrates the methodology used. Sample calculation using Sports Ground to illustrate:

$$Average\ (\frac{kWh}{annum})\ (based\ on\ SAP\ data) = SAP\ \ Total\ (\frac{kWh}{annum})\ x\ \ \%\ Split\ from\ (\frac{kWh}{annum})$$

$$Average\ (\frac{kWh}{annum})\ (based\ on\ SAP\ data) = 15\,097\,007\ \ x\ 0.301\ = 4\,540\,066.11\ \ (\frac{kWh}{annum})$$

This business plan was developed using Microsoft Excel. The investment cost was determined from past projects, in order to determine an investment cost factor for every R/kWh saved (Annexure C illustrates the R/kWh investment factor required for Sport Recreation and Amenities facilities). This exercise highlighted the need for improved data and further data collection, to establish the R/kWh investment factor, which would allow determination of the investment cost required. It is important that the investment cost factor of this business plan be revised and updated with project information each year. The business plan and energy target developed for the two pilot departments and discussed in chapter 6 was developed using the method described in the following section. Table 3.4 illustrates the five-year energy efficiency business plan and energy target developed for the Sports Recreation and Amenities Department. The first column represents the interventions and facilities to be focused on during the five year period. The second column represents the technology type in

Sports Recreation and Amenities Department, the third column represents the electricity consumption per technology type. The savings in kWh/annum column is determined by the percentage penetration column. The percentage penetration column is made up of assumptions. The assumptions were based on interviews and on previous industry experience from the various technologies and past project savings achieved on these equipment type interventions.

The following equation is used to determine the savings in kWh/annum:

$$Savings\ (\frac{kWh}{annum}) \ = \ \%\ Penetration \ \ x \ \ Equipment\ type\ \left(Electricity\ consumption\ per\ annum\ (\frac{kWh}{annum})\right)$$

Sample calculation for Sports Grounds, Community Centres and Swimming Pools for equipment type Lighting:

$$Savings\ (\frac{kWh}{annum}) \ = \ 0.15 \ \ x \ \ 8\ 609\ 823\left(\frac{kWh}{annum}\right) \ = \ 1\ 291\ 473 \ \left(\frac{kWh}{annum}\right)$$

The Savings in Rands is determined using the following equation and showing the sample calculation for the Sports Grounds, Community Centre and Swimming Pools for the equipment type: lighting:

$$Savings\ (\frac{Rands}{annum}) \ = \ Electricity\ tariff\ (Rands) \ \ x \ \ Savings\ (\frac{kWh}{annum})$$

$$Savings\ (\frac{Rands}{annum}) \ = \ R1.44 \ \ x \ \ 1\ 291\ 473\left(\frac{kWh}{annum}\right) \ = \ R\ 1\ 859\ 722 \ \left(\frac{Rands}{annum}\right)$$

The indicative investment cost was determined using the following calculation and showing the following sample calculation for the Sports Grounds, Community Centre and Swimming Pools for the equipment type; lighting:

$$Indicative\ Investment\ Cost\ (Rands) \ = \ Investment\ factor \ \ x \ \ Savings\ (\frac{kWh}{annum})$$

$$Indicative\ Investment\ Cost\ (Rands) = 22(\frac{Rand}{kWh})\ x\ 1\,291\,473(kWh/annum) = R28\,412\,416$$

The simple payback period is calculated using the following equation and showing the following sample calculation for the Sports Grounds, Community Centre and Swimming Pools for the equipment type; lighting:

$$Simple\ payback\ period\ (years) = \frac{Indicative\ Investment\ Cost}{Savings\ (\frac{Rands}{annum})}$$

$$Simple\ payback\ period\ (years) = \frac{R28\,412\,416}{R1\,859\,722} = 15$$

The simple payback period equation does not use the higher than inflation electricity price increase. In real terms the payback periods will be shortend.

The energy target is determined using the following equation and illustrated using the following sample calculation:

$$Energy\ Target\ (\%) = \left(\frac{Total\ Savings\ (\frac{kWh}{annum})}{Total\ Electricity\ consumption\ (\frac{kWh}{annum})}\right)\ x\ 100$$

$$Energy\ Target\ (\%) = \left(\frac{2\,566\,492}{15\,097\,007}\right)\ x\ 100 = 17\%$$

Table 3.4: Sports Recreation and Amenities Department five year energy efficiency business plan

Facility Categories to focus on	Equipment type	Electricity consumption/ annum (kWh/annum)	Target saving %	Savings kWh/annum	Savings Rand/annum	% Penetration	%Savings per technology	Investment factor (R/kWh)	Indicative investment cost (Rands)	Simple Payback period
Sports Ground, Community Centres and Swimming Pools	Lighting	8 609 823		1 291 473	1 859 722	15	40	22	28 412 416	15
	HVAC	333 644								
Swimming Pools	Hot water	2 699 345		564 553	812 956	21	30	2.3	1 298 472	2
	Office Equipment	2 092 445								
Swimming Pools	Pumps	1 361 750	**17**	408 525	588 276	30	30	18	7 353 450	13
All SRA facilities	Smart meters	-						50 smart meters per annum	2 500 000	0
SRA staff	Capacity building and training	-		150 970	217 397			20 staff per annum	500 000	2
SRA staff and tenants at facilities	Awareness raising and Behaviour Change	-		150 970	217 397			N/A	500 000	2
Total		**15 097 007**		**2 566 492**	**3 695 748**				**40 564 338**	**11**

d) Direct observation

Question 3 of the research question, “What is the business model needed in order to enable the implementation of energy efficiency programmes within the City of Cape Town’s internal operations beyond the guaranteed funding period?” The future business model was then presented to a group of 15 key officials of the City of Cape Town, in order to gain general perceptions and insight into whether the proposed business model would be accepted and could be sustained across departments. Annexure A presents the attendance register of the Facilities Optimization Group as proof. Responses and personal observations were recorded in the form of meeting minutes, field notes and email correspondence with participants. These gave further insight into the proposed business model presented, which in turn assisted in answering question 3.

A combination of mixed methods was required in order to answer research question 3. The business model required an in-depth explanation of the organisational and policy framework of the City of Cape Town’s internal operations. Presentations to various key City officials assisted in gaining an understanding of whether this business model will be considered for adoption by the City of Cape Town. The literature review that was conducted highlighted the importance that policy, and the adoption of targets, plays within departments. This encouraged the development of the Internal Energy Management Protocol, which will form the policy layer used to assist departments in implementing energy efficiency within their own operations. The development of departmental targets is discussed in chapter 6. The fieldwork consists of data collection through conducting energy audits at facilities. This assisted in closing the data gaps identified in the data requirements and necessary in order to develop the business model. The results of the business model are presented in chapter 6.

3.3 Summary

The use of mixed methods was the appropriate methodology of choice for this study as it allowed the problem to be viewed from different vantage points. The City of Cape Town’s internal energy efficiency programme formed the case study of this research. A variety of instruments were used in order to collect and analyse the data required to answer the research questions. The application of triangulation methodology applied to all three research questions worked well, as it validated aspects of the qualitative data gathered and provided a rich and in depth analysis of each of the research questions of this study. Chapter 4 presents the case study with chapters 5 and 6 presenting the results from the instruments and methods used in chapter 3.

4 Case Study – City of Cape Town's internal energy efficiency programmes

This chapter presents the results of the case study focusing on the City of Cape Town's internal energy efficiency programmes. The chapter provides an overview of the energy consumption of Cape Town and aims to illustrate the proportion of electricity the City of Cape Town as a single entity consumes. A broad overview of the energy efficiency strategy and energy and climate action plan of the City of Cape Town is given. These policies have been the key drivers of energy efficiency programmes within the City of Cape Town's internal operations. This case study is written in two parts. Section 4.14.1 from, page 74 to section 4.7 on page 102, gives an overview and assesses the energy efficiency programmes implemented up 2016. Section 4.8 on page 105 to section 4.12 on page 120, gives an overview of future business models which aim to continue implementing energy efficiency programmes within the City of Cape Town's internal operations. This chapter further highlights the key areas of energy efficiency programmes, which have been initiated and focused on over the period 2010 to 2016. The background to the key departments that have been implementing and driving energy efficiency within the City of Cape Town's internal operations is also discussed. Lastly, the future business model for continued implementation of energy efficiency programmes within the City of Cape Town's internal operations is described.

4.1 City of Cape Town: an introduction

Cape Town is the second largest metropole in South Africa, with an estimated population of 3.9 million (Cape Town, 2015a). The City of Cape Town employs over 25 000 people, making it one of the largest employers in the Western Cape. The City of Cape Town provides services for all its citizens through a variety of factors, such as water, electricity, waste removal, sanitation, new infrastructure, roads, public spaces, facilities, housing developments, the upgrade of informal settlements, libraries, clinics and more. The city owns and manages over 5 000 facilities, namely: libraries, clinics, sports grounds and administrative buildings. In order to deliver these services, the city uses, on average, an estimated 449 977 809 kWh/annum of electricity (Cape Town, 2015a). As a single entity it is the largest user of energy within the Cape Town metropole. It is responsible for consuming 2 204 190 gigajoule of all energy, 449 977 809 kWh/annum of all electricity and emits 503 635 tonnes of carbon (Cape Town, 2015a). The City of Cape Town has a huge role to play and should lead by example by reducing the electricity consumption of its own internal operations (Cape Town, 2015a).

The city's Energy and Climate Change Unit, part of the Environmental Resource Management Department, has been driving initiatives around energy and climate change. The City of Cape Town was the first municipality in the country to develop an Energy and Climate Strategy (2006). This enabled the City of Cape Town to develop a variety of reports on the state of energy usage, gain political support, develop an energy and climate action plan (2011) and establish a dedicated team to drive energy and climate matters in the City of Cape Town. This framework has initiated the implementation of various energy and climate change programmes within the City of Cape Town. This section aims to explore and assess to what extent the energy efficiency programmes within the City of Cape Town's own operations have been implemented effectively, and what the challenges and benefits are of implementing energy efficiency within the city's own operations.

4.2 Cape Town's energy profile

Cape Town consumed a total of 158 685 055 GJ of energy during 2012 with resulting global greenhouse gas emissions equivalent to 5.2 tCO_2e per capita (Cape Town, 2015a). This is on par with Europe's average per capita emissions. Figure 4.1 illustrates the energy consumption by source in Cape Town. Electricity makes up 29% of this total energy consumption, which represents 6% of the national electricity consumption and 57% of the Western Cape province's electricity consumption (Cape Town, 2015a).

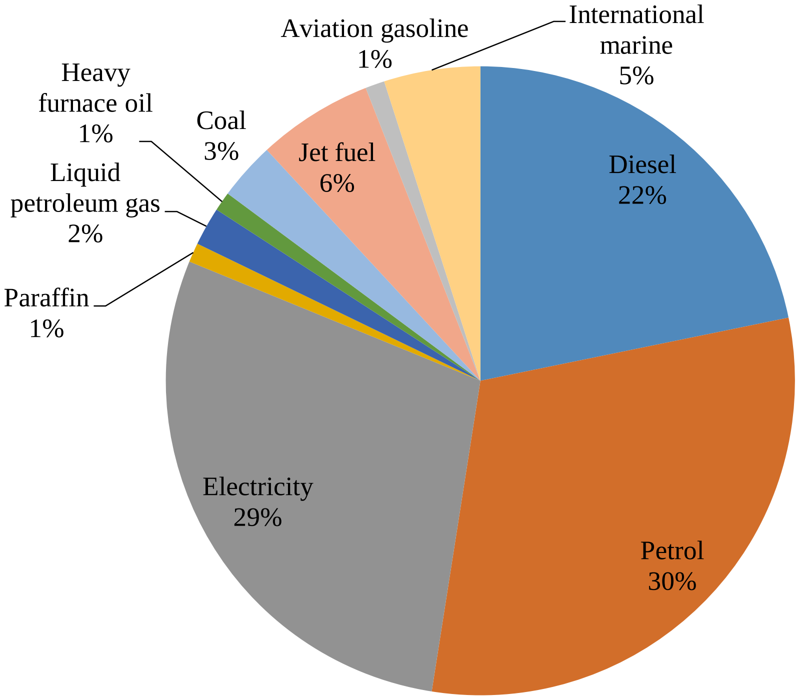

Figure 4.1 Cape Town's energy consumption by energy source

Source: State of Energy Report 2015 (Cape Town, 2015a)

Figure 4.2 illustrates the electricity consumption by sector in Cape Town. The City of Cape Town, as an organisation, is one of the largest single consumers of electricity in the Cape Town region, consuming 4% of the total electricity in Cape Town (Cape Town, 2015a). This 4% electricity consumption does not include provincial and national government consumption. Provincial and national government consumption is captured in the commercial sector electricity consumption (Cape Town, 2015a).

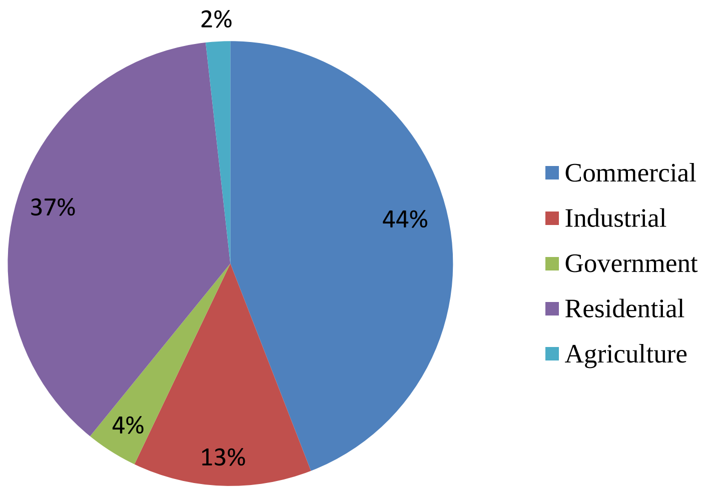

Figure 4.2: Cape Town's electricity consumption by sector

Source: State of Energy Report 2015 (Cape Town, 2015a)

Electricity makes up 74% of the total energy use within its own internal operations, as depicted by Figure 4.3. Electricity is predominantly used in buildings, wastewater treatment plants, and street lighting, as illustrated in Figure 4.4.

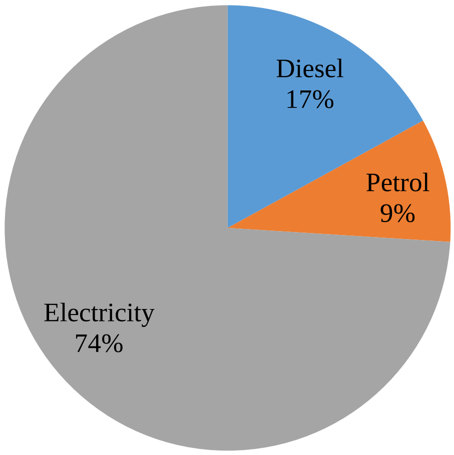

Figure 4.3: City operations energy consumption by source

Source: State of Energy Report 2015 (Cape Town, 2015a)

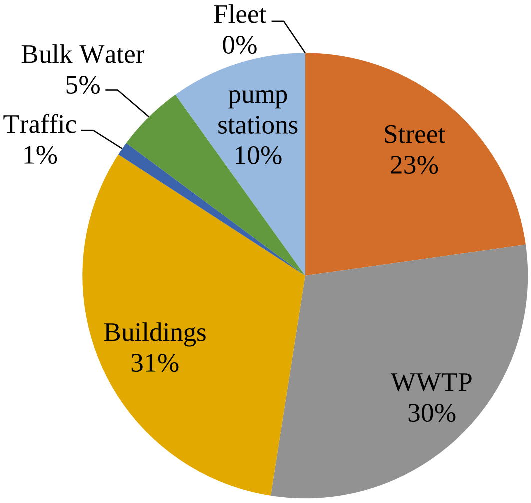

Figure 4.4: Local government's electricity consumption by sector

Source: State of Energy Report 2015 (Cape Town, 2015a)

Figure 4.4 illustrates further how the 4% electricity consumption is made up of. Historically, the broader landscape for electricity generation and consumption in South Africa has been characterised by resource abundance and cheap prices, which fostered behaviour of inefficiency in consumption practises across all sectors. Local government is no different: government buildings, which account for 32% of the City's electricity consumption, are highly inefficient users of energy (Cape Town, 2015a). The use of inefficient building materials together with the historically common practice of conservatively over-specifying equipment designs, contributes to this inefficiency. However, the external landscape for electricity that once enabled such inefficiencies has changed significantly in the last several years. Faced with rolling blackouts, tightly constrained generator capacity, sharply rising prices in the electricity sector and growing pressure on cities to act on climate change, there are strong external pressures to reduce and conserve electricity use (Christoforidis *et al.*, 2013: 643–655).

4.3 Energy efficiency programmes in the City of Cape Town's internal operations

The City of Cape Town has been involved in energy efficiency programmes since 2003. Since 2010, the Environmental Resource Management Department has consistently led various projects and programmes introducing energy efficiency in the City of Cape Town's own operations. These energy efficiency initiatives have resulted in savings of approximately R110 million in electricity expenses with an investment cost of R160 million for the City of Cape Town during the period 2009 to 2014. Using 2007 as a baseline, this is equivalent to a 15% savings (65 832 MWh) from street lighting, traffic lighting and building lighting, from energy efficiency programmes implemented for the period 2009 to 2014.

The City of Cape Town's energy efficiency programme, within its own operations, has been a long and steady build-up of project implementation, data collection and strategy development. It has drawn financial and project support from diverse sources, including international donors, national government grants and - more recently - contributions from municipal revenue. This is part of a larger progression, from information gathering and awareness raising (energy audits); to donor-funded pilot projects primarily aimed at assessing the feasibility and benefits of energy efficiency technologies (Heating Ventilation Air-Conditioning, Solar Water Heater, Light Emitting Diodes etc.;) to funding by national government for Energy Efficiency Demand Side Management retrofits. The City of Cape Town eventually invested its own funds in energy efficiency projects. This is to ensure that energy efficiency implementation within the municipal infrastructure becomes part of the standard institutional setup and operating environment.

Creating the necessary policy and strategy framework has been an important contribution to energy management in general. No action in the City of Cape Town can be driven without aligning with the overarching policy and strategic vision for the organisation. The development and supporting policy framework has created an enabling environment, which supports the internal City of Cape Town operations energy efficiency programme. The Energy and Climate Change Action Plan (City of Cape Town, 2011), which has 11 objectives, focuses solely on driving climate change mitigation initiatives across various sectors within the City of Cape Town (Cartwright, et al., 2012). This policy document set a target of 10% energy reduction in municipal operations by 2012 (City of Cape Town, 2011). Initial data collection and energy modelling to produce "State of Energy" reports, led by the Environmental

Resource Management Department, played a vital part in the eventual formulation of these policy documents. The policy framework, however, is only part of the process towards implementation. It provides the potential for further action, but by no means ensures this will follow.

Understanding actors, their interests, their capacity and commitment, and their political alignments is of fundamental importance in this context. In this case, the municipal institutional context and the opportunities and barriers to innovation and cross-departmental collaboration (Rashid, Sulaiman, Aziz, Selamat, Mat Yani, *et al.*, 2011; Reddy, 2013).

Table 4.1 is a timeline of events marking key turning points during this journey of energy efficiency within the City of Cape Town's own operations. In 2011 the Department of Energy issued the City of Cape Town with a non-compliance letter due to the lack of reporting on the Energy Efficiency Demand Side Management programme. The Environmental Resource Management Department proposed itself as the overall co-ordinating department, taking on the role of reporting and monitoring the progress of the projects and engaging with the Department of Energy. Figure 4.5 is a graphical illustration of Energy Efficiency Demand Side Management programme structure and actors. This new arrangement allowed other departments to focus on the project implementation aspect of the programme and was pivotal as the Environmental Resource Management Department used the opportunity to review and engage with the Department of Energy on the nature of the grant. The Department of Energy subsequently allowed energy efficient buildings retrofit projects as well as capacity building and public awareness programmes to be part of the Energy Efficiency Demand Side Management grant. This shifted the emphasis of the grant from being a public lighting Energy Efficiency grant, to being an all-inclusive Energy Efficiency grant supporting projects across a range of municipal infrastructure, such as buildings, waste water treatment plants.

2012 can be considered another pivotal year the City of Cape Town was excluded from the Energy Efficiency Demand Side Management programme with no funding to implement Energy Efficiency projects. This allowed the Environmental Resource

Management Department to be strategic and re-evaluate its current Energy Efficiency projects and progress. This time was used to write the first internal City of Cape Town operations savings report, which clearly showed the financial impact of the Energy Efficiency projects. The energy savings report was presented to the Chief Financial Officer and the Energy and Climate Change Committee. As a result, in 2013 the City of Cape Town dedicated funds to continue driving Energy Efficiency within its own operations for the first time. This gradual build-up of Energy Efficiency projects into a programmatic approach, allowing year on year implementation. Cilliers (2005c) states the importance of a certain "slowness": taking some time to reflect and evaluate the impact of decisions before making further decisions.

Table 4.1: Overview and timeline of events on implementing energy efficiency in municipal operations

Year	Timeline of events
2003	First "State of Energy" report developed
2003-2004	Energy Audits of 13 Corporate Services large administrative buildings conducted. Showed the importance and value of energy audits. Retrofitted 3 buildings - results showed key effects, and generated experience, especially on the types of data you need to collect and how and where to collect it. Showed technologies were sound and that there were clear benefits.
2004	First energy audit of Civic Centre conducted (sponsored energy audit by an Energy Services Company)
2006	Climate change strategy for City developed City created energy and climate change posts
2007	State of Energy report developed- better data collected
2009-2010	Danida-funded 4 full buildings retrofit project City funds detailed energy audit for Civic Centre 2009: First Energy Efficiency Demand Side Management money received from Department of Energy – goes to electricity department for Energy Efficiency (streetlights).
2010	Energy and climate change action plan adopted by Council Second tranche of Energy Efficiency Demand Side Management funds received- electricity department and traffic department still manages funds.

	Streetlights and traffic lights retrofitted
2011	City issued with a non-compliance letter by Department of Energy due to lack of reporting on Energy Efficiency Demand Side Management progress. Third tranche of Energy Efficiency Demand Side Management funds received – Environmental Resource Management Department starts managing and playing an overall co-ordination role of Energy Efficiency Demand Side Management funds. Allows for Energy Efficiency buildings retrofit projects, street lighting and traffic lighting retrofit projects.
2012/13	Missed out on Department of Energy, Energy Efficiency Demand Side Management funding – No reason provided by DoE
2012	Automatic Meter Infrastructure (AMI) Smart metering project – 55 buildings funded by Energy & Environment Partnership (EEP) First rooftop solar PV system developed and implemented by Environmental Resource Management Department First savings report submitted to Energy Committee
2013/14	City provides funding for Energy Efficiency projects to Environmental Resource Management Department
2013	City provides funding for Civic Centre Energy Efficiency lighting retrofit Fourth tranche of Energy Efficiency Demand Side Management funds – Energy Efficiency buildings retrofit including behaviour change, capacity building, smart metering. IBM Smart City report launched – leads to the establishment of the Facilities Optimisation Working Group.
2014	Second rooftop solar PV system developed and implemented in two Specialised Technical Services buildings.
2015	Fifth tranche of Energy Efficiency Demand Side Management funds received – Energy Efficiency buildings, smart metering, street lighting LightEmitting Diode pilot, capacity building and behaviour change. City funds assigned to Energy Efficiency buildings programme. Energy audits of City

	facilities continued. Energy Data Management system developed with smart metering data. Internal Energy Management Protocol initiated with two pilot departments – Sports Recreation and Amenities (SRA) and STS

Source: Cape Town (2015a)

Creating the necessary programme structure to manage the Energy Efficiency Demand Side Management programme was a critical step. This not only allowed departments to focus on their core strengths, but it also created the framework for collecting data on the energy efficiency projects within internal operations. Figure 4.5 shows the Environmental Resource Management Department as the overall project co-ordinator with various actors in the City of Cape Town and National Government.

Figure 4.5: Graphical illustration of programme management and actors in the energy efficiency demand side management programme

Source: Cape Town (2015a)

4.4 Review of the street lighting electricity efficiency programme

The City of Cape Town estimates that it has approximately 250 000 streetlights, of which 80% comprise 80W to 70W mercury vapour (MV) streetlights, with the balance being high wattage streetlights ranging from 400W to 125W High Pressure Sodium Vapour (HPSV). The Electricity Services Department (ESD) and the Traffic Signal Department (TSD) are both operational in nature, which means that they are technical and service delivery orientated.

The Electricity Services Department welcomed the overall co-ordinating role of the Energy Efficiency Demand Side Management programme assigned to the Environmental Resource Management Department. This meant that the Electricity Services Department could focus purely on the implementation of the retrofit programme. The Environmental Resource Management Department did not assist the Electricity Services Department with the technical aspect of the projects identified by the Electricity Services Department as part of the Energy Efficiency Demand Side

Management programme. The Electricity Services Department has the necessary skills and competency to design, manage and implement these projects. The Environmental Resource Management Department's role is purely an administrative one, to ensure that the project meets funding conditions and that the data and reports are developed for reporting requirements.

The second phase of the Energy Efficiency Demand Side Management programme managed by the Department of Energy came into effect in 2012. The conditions of the second phase of the Energy Efficiency Demand Side Management programme changed drastically. The focus was now on energy efficiency across the entire municipal infrastructure spectrum (not only public lighting) with a particular emphasis on only accepting proposals for energy efficient technologies.

The Electricity Services Department was reluctant to put in a project for a pilot Light Emitting Diode street lighting project for the 2013 financial year. The Electricity Services Department held a firm view that the technology on the market was not mature and that there were other technical parameters, such as luminosity per watt and flux levels, which they were not convinced that the Light Emitting Diode technology could meet at the time. Through engagement from the Environmental Resource Management Department, the Electricity Services Department used the Energy Efficiency Demand Side Management grant to develop a street lighting LED pilot programme, in order to test the technology on the market at the time, but to also test all other technical parameters they required clarity on. A pilot street lighting LED programme is currently being implemented during the 2015 to 2016 Energy Efficiency Demand Side Management programme. The street lighting LED project consists of a very small number of fittings being tested across five different areas of the Cape Town Metropole.

The electricity services department is an operational and service delivery orientated department; they require thorough understanding of all variables to be tested before adopting or incorporating any new technology into their system. This has led the electricity services department to take a conservative approach to implementing LED street lights. They want to ensure that they are developing and introducing the correct technology, as they do not want to stock a variety of fittings from different suppliers in the City of Cape Town. They also want to ensure that they do not need to change the pole lengths and dimensions to still achieve the necessary lux levels as per the stipulated regulations for street lighting, while also ensuring that cost is kept within a reasonable limit. It has been agreed that, should the pilot LED street lighting project yield desirable results, the City of Cape Town will be switching to Light Emitting Diodes for all their streetlights. These are all valid factors that need to be taken into consideration before introducing a technological change in street lighting.

From an organisational perspective it is important to be able to strike a balance between two different departmental goals. The Environmental Resource Management Department wants to drive energy efficiency across the City of Cape Town's own operations as quickly as possible, while the Electricity Services Department's core mandate is keeping the lights on, i.e., delivering services. This proved to be a critical issue when striking a balance between the two department's goals.

4.5 Review of the traffic lighting electricity efficiency programme

The City of Cape Town currently (2016) has approximately 1500 traffic light intersections. All of the traffic lights used to have incandescent and halogen light bulbs. These were retrofitted to Light Emitting Diodes through the Energy Efficiency Demand Side Management programme by 2012. The City of Cape Town was one of the first three municipalities in the country to retrofit all of its traffic lights to Light Emitting Diodes by 2012. The Traffic Signal Department, which forms part of the Transport Department, is responsible for managing all the traffic lights in the City of Cape Town. The Electricity Services Department included the Traffic Signal Department in its operations in the second year (2010) of the Energy Efficiency Demand Side Management phase 1 programme. What is important and interesting to note is that the conditions of the grant funding were not explained to the Traffic Signal Department. The conditions of access to the grant required detailed records of the installation, the reporting requirements and the parameters of the funding.

The Traffic Signal Department thought that the Energy Efficiency Demand Side Management allocation was only meant to procure the traffic lighting fittings and thus would enable them to retrofit all the traffic lights in the City of Cape Town. They used their own funding to upgrade the software and install the Light Emitting Diodes. This meant that they had to change their entire business operation, as the Light Emitting Diodes were an entirely new technology. When the Environmental Resource Management Department began managing the Energy Efficiency Demand Side Management grant during 2011, the third year of the programme, the grant conditions were explained to the participating departments. The Traffic Signal Department decided to continue to use the grant funding for the procurement of the Light Emitting Diodes fittings and that they would continue to use their own funding for the software and installation of the traffic lighting Light Emitting Diodes. Thus the interaction with the Traffic Signal Department was very different from that with the Electricity Services Department. They were committed and wanted to change their entire business operation to be more energy efficient. This commitment was seen from a very high level within their department. Currently all new traffic intersections to be developed through external contractors are required to use Light Emitting Diodes.

4.6 Review of the building energy efficiency programme

It is estimated that the City of Cape Town has over 5 000 facilities namely; libraries, clinics, sports grounds and administrative buildings, which house a number of internal City of Cape Town departments (IBM, 2013). The City of Cape Town has a number of facilities such as libraries, mechanical workshop depots, solid waste depots, wastewater treatment depots, clinics, City Parks depots, Sport and Recreational parks and facilities and administrative buildings, which are poorly managed. This is due to the fact that each department has very different objectives and skills, and each department has to manage their own buildings. This has resulted in most of the buildings and facilities being in poor condition. Resources are not managed properly, making these facilities resource intensive. Figure 4.6 illustrates that the predominant departments consuming electricity are Corporate Services, the Specialised Technical Service Department and Clinics. From Figure 4.6 it can be seen that the Corporate Services, Specialised Technical Services Department consumes almost half the portion of electricity allocated to the buildings and facilities, this due to the nature of the buildings being large corporate administrative buildings which are inefficient. The Corporate Services, Specialised Technical Services Department is responsible for all the City of Cape Town's large administrative buildings that explain why they are the most electricity intensive users. In Figure 4.6 the acronyms SRA stands for Sports Recreation and Amenities Department and TCT stands for Transport Cape Town Department.

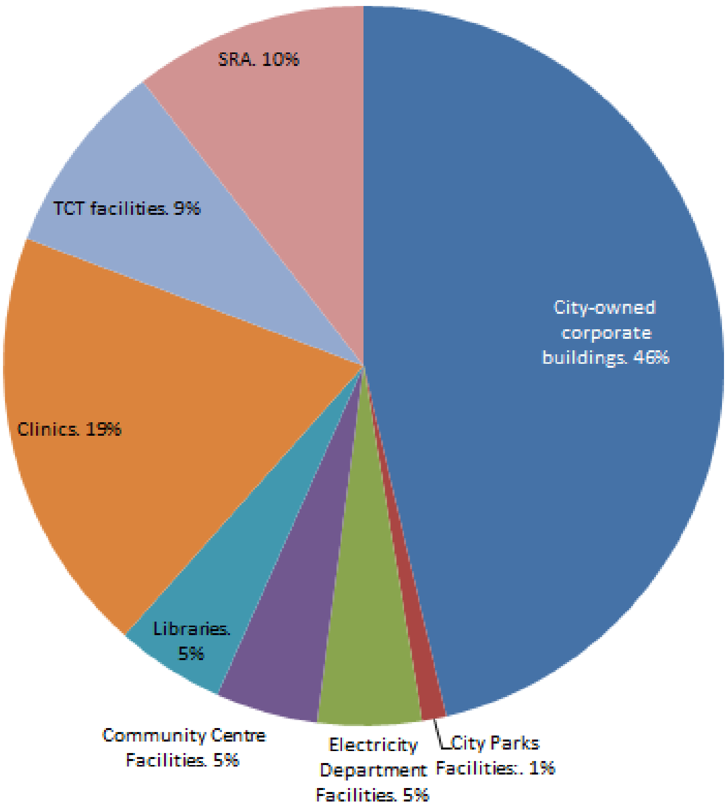

Figure 4.6: Internal City of Cape Town operations buildings and facilities electricity consumption

Source: Cape Town (2015a)

The Environmental Resource Management Department has a steady and good relationship with Corporate Services, Specialised Technical Services Department. The Environmental Resource Management Department used the opportunity to partner and work with Specialised Technical Services in order to understand how make their own buildings more energy efficient. The relationship between Environmental Resource Management Department and Specialised Technical Services has been one where the Environmental Resource Management Department has developed the technical capacity to drive energy efficiency within the City of Cape Town's buildings. Specialised Technical Services has created an enabling and supportive environment to allow these energy efficiency initiatives. The role played by the Environmental Resource Management Department in the City of Cape Town's buildings, is very different to the role it plays with more technically competent departments, such as the Electricity and Transport Department.

The Environmental Resource Management Department's role within the City of Cape Town's buildings has been one of developing funding proposals to access grant funding in order to implement energy efficiency projects within City of Cape Town buildings, It collects data, sets baselines for buildings, develops the technical specifications for tenders, manages the implementation of tenders and monitors the energy savings from initiatives implemented in buildings identified for an energy efficiency retrofit programme. This is more than facilitation and monitoring role and it has led to valuable insight and the development of technical skills within the Environmental Resource Management Department when it comes to energy efficiency within City of Cape Town buildings.

The first energy audits of 13 Corporate Services administrative buildings were conducted in 2003. These audits revealed the importance and value of energy audits. The energy audits within these buildings revealed a key problem within City of Cape Town buildings and facilities. The building manager did not have access to or know where to find his electricity and water bill. This highlights the problem of the 'invisibility' of electricity and water as important input parameter for departments who wish to fulfil their service delivery mandates. Despite the importance of these resources as an input, they are 'hidden' due to faulty operational and management terms. The City of Cape Town processes all its internal facilities and building utility cost through a centralised system. In the absence of proper metering and data collection, systems at disaggregated level, departments are not directly responsible for their electricity and water bills.

All the bills for the City of Cape Town facilities and buildings, which fall within the City of Cape Town's electricity distribution networks, are paid by the Electricity Services Department, as part of the bulk purchases made from Eskom. The Electricity Services Department passes this cost on to departments but this is merely an accounting exercise. Departments with facilities and buildings, which fall within the Eskom supply area, are directly responsible for managing and paying their own electricity bills. The challenge remains, as departments do not have access to their energy data and lack the capacity and skillset to effectively understand and manage their consumption. Electricity and water bills are just being paid, but there is no proper monitoring and control.

Table 4.2 summarises key building energy efficiency projects. It will be explained in phases, as each phase has a different strategy contributing to the current more co-ordinated and strategic approach that is envisioned in order to further drive energy efficiency within the City of Cape Town's buildings and facilities. Phase 1, which saw the very first energy audits being conducted in 13 large corporate administrative buildings, led to grant funding being accessed and the first three full building energy efficiency retrofits being implemented. Figure 4.7 shows the energy consumption distribution profile developed for each of the buildings. It illustrates that lighting, office equipment and heating, ventilation, air conditioning and cooling are the predominant energy consumption technologies in a building.

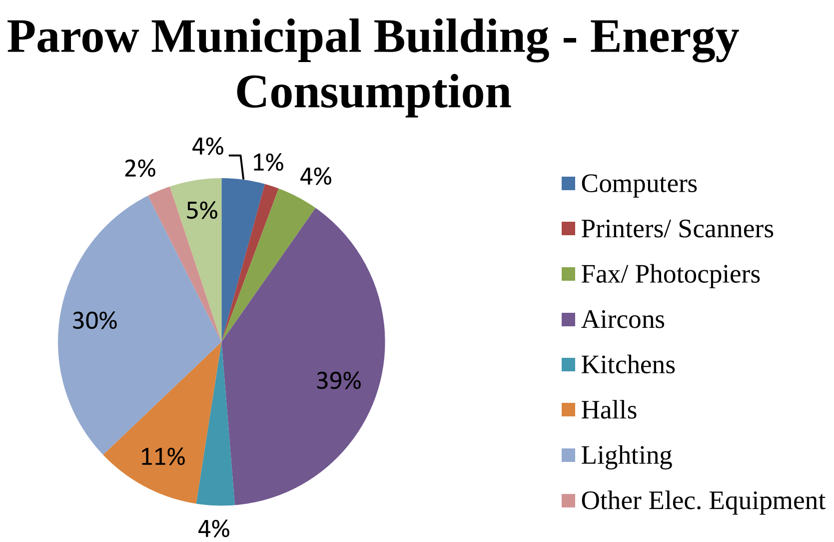

Figure 4.7: Example of energy audit consumption distribution at one of the buildings forming part of the energy efficiency phase 1 programme retrofit

Source: City of Cape Town (2004)

Table 4.2: Summary of building energy efficiency programmes within the large corporate administrative buildings

Year	2003/4	2009/10	2011/12	2013/14	2014/15 and 2015/16
Phase	**1**	**2**	**3**	**4**	
Technology retrofits	Energy Efficient lights (Fluorescent tubes T8), Solar Water Heating, hydro-boils	Energy Efficient lights (Fluorescent tubes T5), SWH and timers, temperature control on HVAC systems, timers, Power Factor Correction	Energy Efficient lighting (Fluorescent tubes T5) and motion sensors	Energy Efficient lighting (Light Emitting Diodes) and motion sensors	Energy Efficient lighting (Light Emitting Diodes) and motion sensors and Civic Centre Energy Efficient Lighting project
Behaviour Change programme	Yes	Yes	Yes	Yes	Yes
Capacity Building of building managers (Fundamental Energy Management Training)	No	No	Yes	Yes	Yes
No of buildings	3	4	14	11	1
Smart meters	Yes (but external supplier)	Yes (but external supplier)	Yes (Internal system used)	Yes (Internal system used)	Yes (Internal system used)
Funding Source	Grant	Grant	Grant	Grant	City of Cape Town
Contracting method	No Performance Guarantee Savings Contract	Performance Guarantee Savings Contract	Performance Guarantee Savings Contract	Performance Guarantee Savings Contract	No Performance Guarantee Savings Contract
Savings per annum (kWh/annum)	**210 584**	**521 172**	**546595**	**952 978**	**5 725 350**

Source: Cape Town (2015a)

This information assisted in determining the retrofits to be implemented. These retrofits included: efficient lighting (mainly fluorescent T8s, the most efficient fluorescent technology at the time), Solar Water Heaters, hydro-boils (hot water for tea and coffee), and a behaviour change programme aimed at raising general awareness of the programme and the building's consumption with tenants. It is important to note that, although heating, ventilation, air-conditioning and cooling is the most energy intensive technology in a building; the retrofit did not include upgrades of these systems as it was deemed too costly at the time. Simpler solutions such as timers on the heating ventilation and air-conditioning and cooling systems were introduced.

This project was undertaken in collaboration with the Environmental Resource Management Department, Sustainable Energy Africa, a non-governmental organisation, and Corporate Services, more specifically Specialised Technical Services. The Environmental Resource Management Department's role was to facilitate and work closely with Sustainable Energy Africa, a non-governmental organisation aimed at supporting municipalities in implementing sustainable energy solutions. Corporate Services, Specialised Technical Services Department allowed this project to be implemented within three of its buildings. The City of Cape Town did not procure any materials. Grant funding was secured by Sustainable Energy Africa and they procured the materials as well securing a contractor to install the equipment. The Environmental Resource Management Department worked closely with Sustainable Energy Africa to gain internal capacity and learn how to collect key data to monitor and improve savings. A total savings of 210 584 kWh per annum was achieved across the three buildings. This resulted in an average of 15- 25% savings of total consumption realised through technology retrofits implemented per building.

The most significant lesson learnt through the interventions implemented was the importance of behaviour change. The Behaviour Change programme consisted of a City champion within the building, who posted a weekly poster of the building's electricity consumption profile. Figure 4.8 illustrates one of the posters placed at each of the buildings with their electricity consumption profile visible to all employees. Simultaneously, weekly flyers were distributed with saving electricity messaging informing tenants how they could contribute to saving electricity within their building and at home. A 25% saving was realised across the three buildings through the Behaviour Change programme, Figure 4.9 illustrates the savings from the Behaviour Change programme.

Figure 4.8: Example of behaviour change posters placed weekly in each of the three buildings during phase 1 Energy Efficiency buildings programme

Source: City of Cape Town (2004)

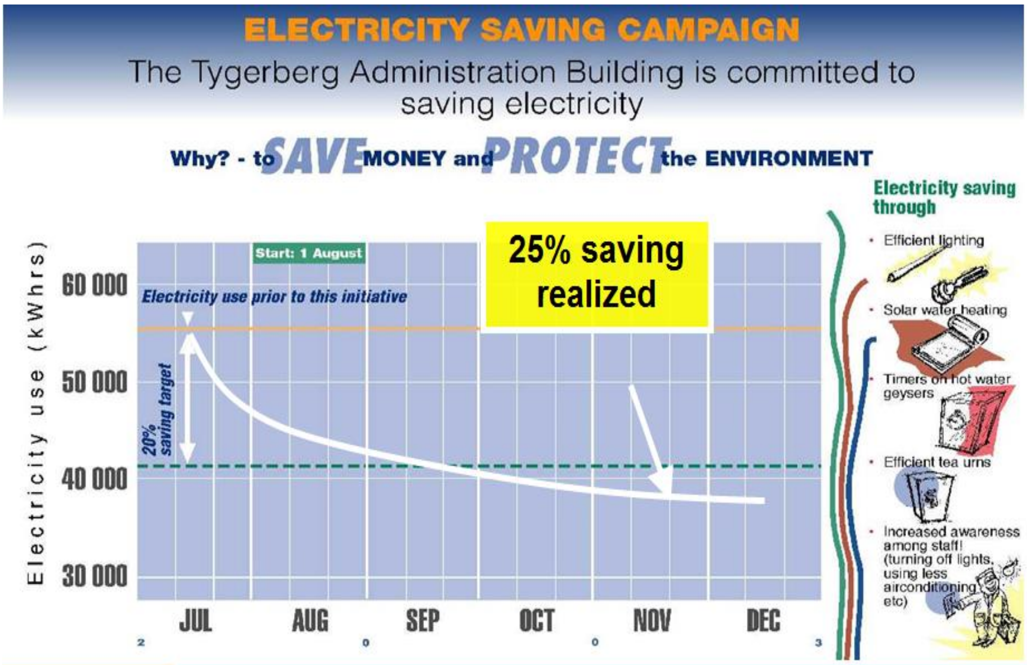

Figure 4.9: Behaviour Change results from phase 1 energy efficiency buildings programme

Source: City of Cape Town (2004)

Phase 2 of the energy efficiency drive within City of Cape Town buildings required a different strategy and approach. This time the Environmental Resource Management Department understood and had learned what was required to develop these projects, and undertook to seek grant funding with the aim of procuring materials and services through the City of Cape Town's supply chain management system. Grant funding was secured from the Danish International Development Agency to implement retrofitting at four more of the large corporate administrative buildings. The Environmental Resource Management Department's role was to develop tender specifications, implement the project, monitor and report on the savings while Specialised Technical Services allowed for the interventions to be implemented within their buildings.

The Environmental Resource Management Department acknowledged the challenges faced with procuring materials and goods through the City of Cape Town's system, and decided to develop a performance guarantee savings contracting mechanism. Due to the lack of expertise and the fact that energy efficiency technology was not matured at the time, this form of contracting was best suited to mitigate the risk of procuring materials that would not achieve the desired savings for the project. The appointed company was awarded the opportunity to conduct a full energy audit and develop a detailed energy efficiency implementation plan, specifying the technology needed and the savings that could be achieved. A two year historical energy consumption baseline was established and agreed upon before the retrofit for the building

The contractor guaranteed the savings by converting the savings from kWh to a currency value and supplies the City of Cape Town with a bank guaranteed cheque to the value of the savings each year. A smart meter was installed and the City of Cape Town was given access to the metered data in order to monitor the savings each month. Should the contractor fall short over a period of 12 months on the guaranteed savings per annum, the City of Cape Town then draws the shortfall from the performance savings bank guaranteed cheque. This form of contracting has proven to be very effective. At the end of the contract, should the contractor achieve the savings, the City of Cape Town releases the cheque to the contractor.

This process posed a number of challenges regarding the procurement processes; for instance, the City of Cape Town's supply chain management was not familiar with this kind of contracting mechanism and did not have a system in place to support such a contract. This contract would require a contractor to be appointed in the absence of a total contract award being made. The Environmental Resource Management Department worked closely with the Supply Chain Management department, upon which the Supply Chain Management department developed the following procurement process to make this kind of contracting possible within the municipality. Upon the award to the successful contractor, the contractor is allowed to conduct energy audits and develop full implementation plans for each building. This process allows the contractor to allocate a final financial value to the process of conducting energy efficiency interventions and is thus able to determine the anticipated savings from the interventions being proposed (South African Local Government Association, 2014). The implementation plans are evaluated by the Environmental Resource Management Department and the best plans, with the most financially viable savings, are selected and presented at the City of Cape Town's Bid Adjudication Council. The Bid Adjudication Council consists of a panel of independent City of Cape Town experts from various backgrounds, such as finance, legal, engineering, etc. The Bid Adjudication Council awards a second and final contract value based on the approved financially feasible implementation plans as presented by the Environmental Resource Management Department. A two stage tendering process was put in place to support this kind of contracting (South African Local Government Association, 2014).

Figure 4.10 illustrates the effectiveness of a performance guarantee savings contract. The red line represents the targeted monthly savings and the blue line represents the actual savings achieved. The reason for the over achievement of savings is due to the behaviour change programmes which the contractor drives. This ensures guaranteed savings. A number of challenges that remained unsolved upon the completion of phase 2 energy efficiency buildings programme. These were the maintenance of the new technology installed, access to the store items being upgraded and access to the smart meter data for monitoring and reporting purposes.

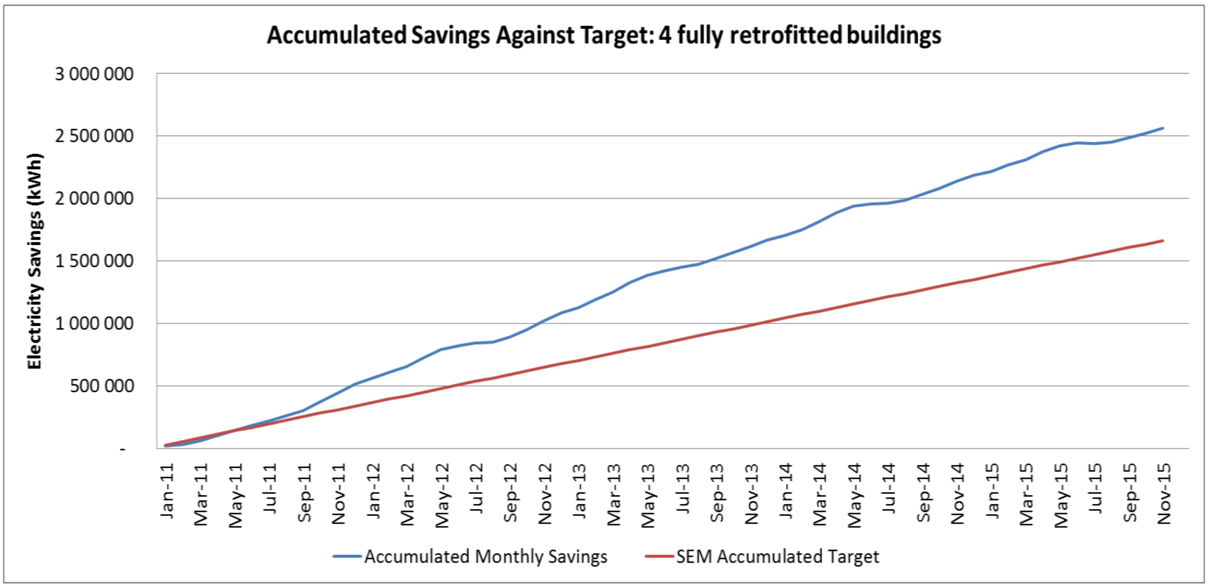

Figure 4.10: Results of performance guarantee savings contract on second phase energy efficiency buildings programme

Source: Cape Town (2015a)

Phase 3 of the energy efficiency buildings programme could be described as a turning point with regards to the relationship between the Environmental Resource Management Department and Corporate Services, Specialised Technical Services. The maintenance of these technologies became a pressing issue as the Environmental Resource Management Department was now monitoring the savings. A number of challenges arose when the savings in two of the buildings were impacted due to a lack of understanding and proper clarification of roles between the two departments. Specialised Technical Services increased the number of staff in two of the buildings; this increased the consumption, but could be managed by adjusting the baseline. The second major challenge presented itself when Specialised Technical Services undertook renovations in two buildings. Contractors installed lights, but it was not specified that the lights needed to be energy efficient. These challenges raised important issues, which required the Environmental Resource Management Department to re-examine of the institutional processes and roles of each department and actor.

The Environmental Resource Management Department engaged with Corporate Services, Specialised Technical Services, and it was agreed that, although the performance guarantee savings contracts reduced the maintenance on Specialised Technical Services, a handover period and training of Specialised Technical Services staff was required. Training of facility managers was identified as an issue. Furthermore, it was essential that store stock items were the responsibility of the Environmental Resource Management Departments, if they wanted to continue implementing energy efficiency within the Corporate Services large administrative buildings. These changes were successful, as there was more engagement and knowledge transferral between the two departments. A shift in the relationship occurred, where Specialised Technical Services department used to allow energy efficiency programmes to be implemented by the Environmental Resource Management department to Specialised Technical Services department developing and implementing energy efficiency programmes and working with the Environmental Resource Management department to make their facilities more energy efficient, This collaborative partnership developed between Specialised Technical Services and Environmental Resource Management department illustrates transferral of skills between the two departments.. With this new understanding being reached a change in strategy from the Environmental Resource Management Department was required.

The phase 3 energy efficiency buildings programme was funded by national government's Energy Efficiency Demand Side Management programme. Energy Efficiency Demand Side Management funding limited interventions to energy efficient lighting within municipal buildings. The second performance guarantee savings contract was developed during this time. The Environmental Resource Management Department included a maintenance training and handover section as part of the contractor's responsibility. The Environmental Resource Management Department also undertook to review all of the building lighting store stock items and ensure that only energy efficient lighting was accessible to all within the City of Cape Town. These measures were all set in place as a result of lessons learnt from phase 2 projects.

The Energy Efficiency Demand Side Management funds made provision for training; the Environmental Resource Management Department developed the following approach to ensure that all actors were part of the energy efficiency buildings programme.

Phase 3 of the building's energy efficiency programme was a critical to the Environmental Resource Management Department. The receiving department Specialised Technical Services, highlighted a number of challenges with the past retrofits implemented. The lessons the Environmental Resource Management Department learnt went beyond getting the technical specification correct and ensuring savings from the technology procured. People are a large influencing factor in the implementation of an energy efficiency retrofit project, and understanding how the people use and manage technology is critical to the process. Figure 4.11 illustrates the key actors identified within large corporate administrative buildings, and details the approach used to ensure that an appropriate engagement methodology was developed for each category of actors.

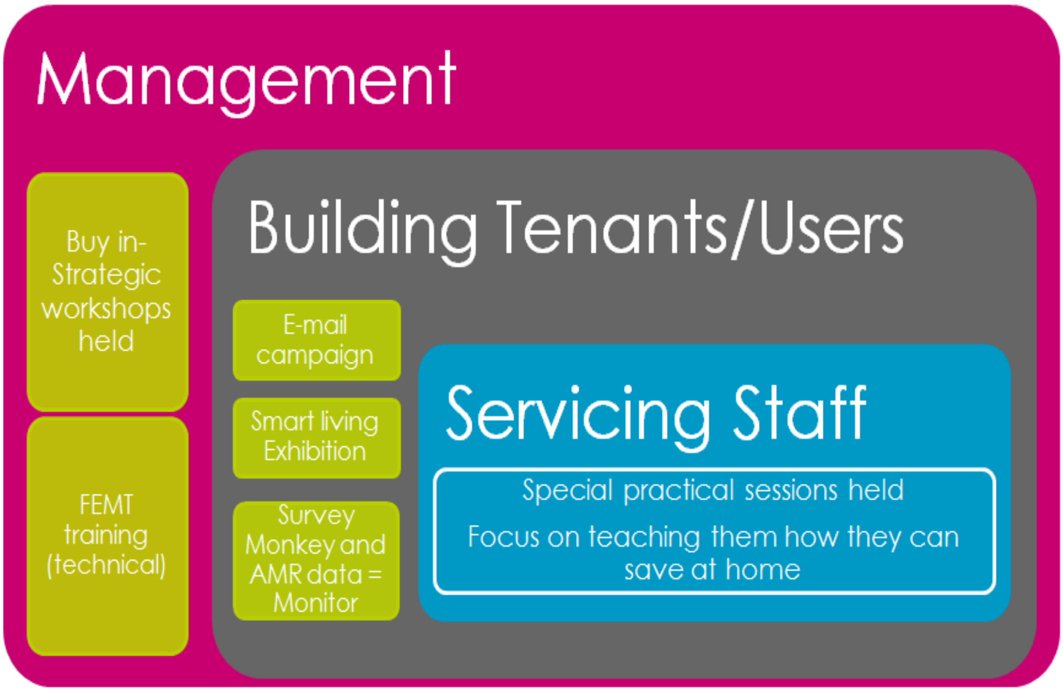

Figure 4.11: Illustrating the different actors forming part of retrofitting a building

Source: Cape Town (2015a)

Each set of actors has a different set of objectives. For the management cluster, depicted in Figure 4.11, buy-in and approval is required, and management acknowledges the investment into the buildings and savings. However, they require that their staff (operational and maintenance) are trained and that processes be developed in conjunction with them to manage this new technology and ultimately reach a new way of managing their facilities. Two workshops were held, one with the management team of Specialised Technical Services, and one with the operational and maintenance teams of Specialised Technical Services. These workshops provided the Environmental Resource Management Department with the necessary insight into the challenges and limitations that they are faced with. This allowed the Environmental Resource Management Department to develop the appropriate training and processes to ensure that sustainable management of the technology was guaranteed. Two sets of training modules were developed, in order to build the Specialised Technical Services management and more technical/operational staff capacity in terms of energy management.

The fundamental energy management training course was developed by a service provider and adapted by the Environmental Resource management department to give the basic fundamentals of energy management to the building and maintenance managers by empowering them to read their building's consumption data and how to informed decisions, thereby assisting them in better management of their facilities. The fundamental energy management course is a five day programme, three days of which are theoretical, focusing on the fundamentals of energy management while also giving participants an overview of the reason that the City of Cape Town requires them to focus on implementing resource efficiency. Participants are then given practical assignments, and after two months, two days are set aside in order to allow the participants to present their findings. More importantly, participants share their experiences during this process. This also allows participants to question trainers regarding specific problem areas that they might require assistance with. This approach has been very effective and feedback from participants has been positive. Further requests for this type of training have been received from other department, illustrating that they value this process. To date, sixty five Specialised Technical Services maintenance and operational managers have been trained.

The second part of the training is more practical and site orientated. This training focuses on the maintenance technicians who have to go out and check new technologies installed on site. As part of the appointed service provider’s job is to provide on-site hands-on training. The handover on-site training takes place over a 12 month period. The service provider explains and illustrates how the maintenance on the specific equipment is conducted while the City of Cape Town staff observe. For the first three months the service provider conducts the maintenance. From month four the service provider starts playing a facilitation role, wherein they are on site, but allow the City of Cape Town staff members to conduct the maintenance under their supervision. This process continues for another three months. In order to further build their confidence during the remaining months, the City of Cape Town staff members have to conduct the maintenance themselves, completing maintenance sheets and handing them to the respective managers and service provider to check. The service provider does spot checks to ensure that maintenance is conducted according to the maintenance manual. At the end of the period a report is submitted, confirming that the City of Cape Town staffs has acquired the necessary skills needed to maintain the technologies installed, or suggesting where further training is required.

As the tenants are the primary users of the building, a specific awareness raising programme was developed by the Environmental Resource Management department based on previous smart living awareness training material developed by the Environmental Resource management department, in order to raise their general awareness around energy efficiency. The approach taken was to teach them how they could save energy at home, with the hope that this would eventually translate to behaviour change in the office space (for example switching off unnecessary lights and equipment not required, reporting leaks). The awareness raising programme for tenants was conducted for each building that formed part of the retrofit. The programme for tenants involved a smart living exhibition, which consisted of four themes namely energy, water, waste management and biodiversity. The programme ran over one week for each building. During the week of the programme, a daily email was sent to tenants, with information on each of the four themes. On the Thursday of each chosen week during the training, the exhibition was hosted in that specific building. On a Friday, a survey was sent to all participants in order to evaluate the effectiveness of the email and exhibition programme.

Each of the building also uses service staff, such as cleaners, tea ladies and security personnel. A specific two hour interactive session was held with this group. The security staff are tasked with ensuring compliance after office hours by checking that all lights are switched off. Training the service staff was key, as their roles are to support the building manager and it was critical that they understood the importance of using resources effectively. The same methodology was used as with the tenants, but was conducted in an intensive 2 hour session The smart living training for tenant and service staff has enabled the training of 667 staff members in phase 3 energy efficiency buildings programme (South African Local Government Association, 2014).

Phase 4 of the buildings energy efficiency programme, saw the City of Cape Town put its own funding towards energy efficiency for the first time. The savings report presented to the Chief Financial Officer and the Energy and Climate Change Committee during 2012, resulted in the City of Cape Town allocating a budget of R3 million per year in order to continue energy efficiency and renewable energy within its own operations. The long-standing relationship of 13 years between the Environmental Resource Management Department and Specialised Technical Services finally translated into Specialised Technical Services investing R45 million, of their own funding, into retrofitting the City of Cape Town's flagship building, the Civic Centre. During this phase the cost and performance of Light Emitting Diode technology had improved drastically, and this saw the introduction of Light Emitting Diode lighting within corporate buildings. The City of Cape Town's funding enabled the Environmental Resource Management Department to install 90kW$_p$ of solar photovoltaic grid tied systems on three of the large corporate administrative buildings. The renewable energy projects were implemented in buildings that had already received energy efficiency interventions. The three large corporate buildings, which have received both energy efficiency and renewable energy interventions, are Gallows Hill, Royal Ascot, and Omni Forum. The first solar photovoltaic project was implemented at Gallows Hill during 2013 with a system size of 10kW$_p$.

A year later, the Environmental Resource Management Department decided to develop another PV project; this time a much larger system of $80kW_p$, as this was the amount of funding it had available. The Electricity Services Department had at this time developed Small Scale Embedded Generation Guidelines and was allowing net metering. This project developed within the context of understanding the Small Scale Embedded Generation guidelines and was implemented in conjunction with the Electricity Services Department, in order to make these guidelines easy to understand for the rest of the public. It is important to note that the initial investigation and site selection, as well as the determination of the size of the system, was done by the Environmental Resource Management Department as this department had the relevant technical experience. Five buildings were identified as suitable for the 80kWp PV system and the tender assigned a consultant to do a detailed assessment of the sites and specify the site that would yield the best return on investment.

The key lesson learnt during this tender, was that it was necessary to make provision for alternative suitable buildings, as the largest constraint was roof integrity. Royal Ascot has enough roof space to accommodate over $100kW_p$ of PV, but due to the roof being in such a poor state, the structural engineer only approved a $20kW_p$ PV system, with the balance being approved at Omni Forum. The structural design of these two systems caused a nine month delay. This was due to a number of challenges, as this is a new field in industry and even structural engineers are learning new skills. For instance, the contractor struggled to appoint a structural engineer who was confident enough to sign off on these systems. Internal delays by the Electricity Services Department added another six to seven months to the execution, resulting in an average turnaround time of two years and six months to complete both projects. These delays have taught us that getting structural sign off on the design is required first before the procurement and installation of the PV systems can go ahead. The Electricity Services Department now has a dedicated team reviewing all Small Scale Embedded Generation requirement applications, and have better systems in place to deal with applications in order to ensure a quicker response rate.

Skills development in the entire PV sector is required this is based on the City of Cape Town's experience, especially in the rooftop PV market. Current Small Scale Embedded Generation specifications require the sign-off of a Professional Registered Engineer. Furthermore, an electrician is required to approve a certificate of compliance for direct current systems.

There are currently only certificates of compliance for alternating current systems. Another major concern is the lack of awareness of current PV installers with regards to the Occupational Health and Safety Act. Not many PV installers are aware that all their workers require working at height training certification. This was another challenge experienced during the 80kW$_p$ PV project. Despite the challenges experienced the total cumulative savings achieved from 2009 up until 2015 resulted in 7 746 095 kWh of electricity savings across the four phases of building energy efficiency interventions implemented this savings includes the savings from the PV projects.

4.7 Data monitoring and reporting of energy savings in the City of Cape Town

The first savings report was developed and presented to the Energy and Climate Change Committee in 2012 (ERMD, 2014). The savings report included all the projects that were funded by the Energy Efficiency Demand Side Management programme, as these projects required strict monitoring, reporting and verification of savings. The monitoring and reporting on savings realised through the energy efficiency projects to date, has resulted in the City of Cape Town recognising the benefits associated with these projects, and committing R 3million per annum to the Energy and Climate Change Unit in order to further drive energy efficiency within the City of Cape Town's own operations. The Energy and Climate Change Unit, is tasked with submitting a savings report on the City of Cape Town operations energy efficiency programmes bi- annually.

The smart metering programme is specifically aimed at getting accurate and easily accessible data of the buildings electricity consumption. In 2012 the City of Cape Town received R1million from the Finnish Embassy, in order to develop an energy management system using smart meters in its operations. This funding allowed the implementation of a strategic project and initiated an energy management system using smart meters within the City of Cape Town's operations. The funding, however, could only pay for 55 smart meters. The Environmental Resource Management Department and the Energy and Climate Change Unit partnered with the Electricity Services Department on this project. The Energy and Climate Change Unit provides the Electricity Services Department with a list of buildings, which require smart meters. The Electricity Services Department is responsible for the technical specifications, installation and maintenance of the meters. They have the necessary infrastructure and back end system in place to collect the data. The Energy and Climate Change Unit and building managers have access to the data. There is no monthly operational fee as this database is managed by the Electricity Services Department. One of the main reasons that the Environmental Resource Management Department partnered with the Electricity Services Department on this project was to ensure that continuous access to the data was secured. During the first buildings energy efficiency projects implemented, smart meters were installed, but access to the data was restricted, as the City of Cape Town had to pay a monthly fee in order to receive the data. Access to the montly data was restricted due to the absence of dedicated funds.

The City of Cape Town's buildings are complex. Many of the large administrative complexes are made up of several buildings, which were not all built at the same time. In an attempt to accommodate these different specifications during the first phase of the smart meter installation, it was decided to only place a smart meter at the main incomer, thereby ensuring that the whole building gets metered. In some instances, due to building extensions, more than one main incomer is required to give a representation of the electricity consumption for the whole complex. The smart metering programme initiated the first capacity building training programmes as explained in section 3.6, and led to the concept of developing an Internal Energy Management Protocol. Developing an energy management system for the City of Cape Town would require building managers and Departments to have access to their electricity data supported by a City of Cape Town framework that encourages resource efficiency within City of Cape Town buildings.

By the 30th of March 2016, the City of Cape Town had installed 484 smart meters across its buildings. This represents 12% of the City of Cape Town facilities (3 000 of which are electricity consuming facilities out of the 5 000 facilities the City of Cape Town owns). The Environmental Resource Management Department is currently extracting and manually updating an Excel file with each building's electricity consumption. Considering the number of buildings with smart meters, this is an onerous task. An energy data management project initiated in 2016 will automate the smart meter data and develop dashboards for the various end users (Managers, Tenants and public).

The third phase of this programme will see each building that has a smart meter, receives a screen that displays the building's consumption profile with a baseline and a set target. Annual funding from the City of Cape Town's R3 million budget has been dedicated to continue the rollout of smart meters in the City of Cape Town buildings.

The City of Cape Town reports to national government on its climate change projects and to various international accords, partnerships and agreements on which it is a signatory (for example the City of Cape Town is part of the Compact of Mayors and this requires the City of Cape Town to report on its climate change projects). These international climate reporting initiatives provide a platform to report transparent local energy and climate actions and data globally, allowing for international benchmarking with other cities and companies.

Data collection, monitoring and reporting is becoming increasingly important. Through the smart metering programme, buildings and facility data is starting to give greater insight into energy consumption. More importantly, a strategy can now be developed to manage energy within City of Cape Town buildings much more effectively by making use of the smart metering data collected to date.

4.8 Development of an Internal Energy Management Protocol for the City of Cape Town

This slow steady development of energy efficiency projects and data collection has created the opportunity to develop an Internal Energy Management Protocol for the City of Cape Town operations. The timing is opportune, as the City of Cape Town's executive management have recognised the need to develop an improved process in which the City of Cape Town's assets are managed more effectively. The current departmental silo mentality is inefficient and costly. An example of this silo mentality being inefficient and costly is best given through the buildings management. Each line department is responsible for the maintenance and upkeep of its buildings. On one plot or piece of land owned by the City of Cape Town you will find a library, a clinic and an administrative building. The clinic, library and administrative building is managed by different departments, each building has its own facility manager and each budget is separate. If there is maintenance required at the clinic, library and administrative building each department needs to procure and manage that aspect of work separately. A better example is where there was a sports ground managed by the Sports, Recreation and Ammenities department and on the same property a library. Each had a garden with grass which required maintaining. The two departments never worked together and each time they would get a separate contractor to cut only their portion of the gardens grass.

The Internal Energy Management Protocol (IEMP) was developed in 2013 by the Environmental Resource Management, Energy and Climate Change Unit, with the following aims and objectives:

1. Reduce the City of Cape Town energy consumption
2. Save the City of Cape Town money by reducing operational expenditure
3. Improve planning and budgeting of energy efficiency
4. Ensure proper monitoring and reporting on energy consumption across operations
5. Improve coordination of energy management interventions
6. Provide effective support for implementation of energy management
7. Define roles and responsibilities
8. Consolidate and align existing and additional projects

This protocol is currently a draft, as it has been challenging to find the appropriate City of Cape Town process in order to formalise it. The City of Cape Town has developed an Immovable Property Asset Management Policy (2014); this policy outlines the broad framework of the manner in which the City of Cape Town intends to manage its assets. It supports the above aims of the Internal Energy Management Protocol and it has been agreed to make the Internal Energy Management Protocol an addendum of the Immovable Property Asset Management Policy (City of Cape Town, 2014). The Immovable Property Asset Management Policy (2014) creates a framework to support detailed standard operating procedures, in order to execute the principles it has unpinned in the policy. This process builds further support from the Executive Management and the Property Management Department. The Internal Energy Management Protocol aims to develop energy targets for departments through 5 year business plans.

4.9 Institutional framework of the City of Cape Town to support and institutionalise energy efficiency within its own operations

In 2013, the City of Cape Town was selected as part of 31 Cities globally, to participate in an IBM Smarter Cities Challenge. The challenge provided the City of Cape Town the opportunity to review its social assets with the view of answering the following question: “How can the City of Cape Town effectively use and manage its social assets to increase service delivery?” (IBM, 2013). The study reviewed the City of Cape Town’s current management model and made some key recommendations with regards to change management and a transversal management approach in order more effectively manage social assets.

The City of Cape Town’s social assets are its libraries, clinics, community centres, halls, sports grounds and sport facilities. These assets are currently being managed in an in ineffective and fragmented manner, thereby increasing the cost of these assets to the City of Cape Town. The City of Cape Town has implemented some of the recommendations made in the IBM (2013) study in order not only to manage its social assets better, but also to deliver better services to its citizens. This study has initiated a process within the City of Cape Town's executive management level to address the manner in which it is managing its assets.

The City of Cape Town created a Property Management Department in 2009, and has tasked this department with putting in place a proper data management system on all its assets. Property management department has developed a policy, which creates a framework outlining the broad principles of the manner in which it wants to manage all of the City's assets. This policy, called the Immovable Property Asset Management Policy (2014), aims to manage the City of Cape Town's assets in a resource efficient manner, thereby ensuring accountability from the necessary line departments. Roles and responsibilities pertaining to the use and management of the City of Cape Town's immovable assets will be defined. This policy will introduce performance measurements in the use, management and control of immoveable assets, better manage facilities through the use of information technology platforms and ensure alignment of assets and use with service delivery requirements (City of Cape Town, 2014). These objectives are in alignment with the Internal Energy Management Protocol and, as stated earlier, will form an addendum to this policy. The City of Cape Town recognises that, in order to drive innovation, it needed to create a platform to initiate a transversal management system. This is to break the silo mentally within the organisation, as this was another key challenge raised in the IBM (2013) smart cities challenge.

In 2012 the Executive management introduced a transversal management system. This structure is an attempt to the current silo mentality that the City of Cape Town is operating in. The aim of the transversal management system is to ensure that all directorates work in a collaborative manner with regards to service delivery, and to improve coordination and integration of service delivery and planning by creating the necessary structures in which both the political and administrative managers can work together and make effective decisions (City of Cape Town, 2015a). Figure 4.12 is a diagrammatic illustration of the City of Cape Town's Council structure. The Council is made up of a political and administrative sphere. The Transversal Management Structure has been introduced to the administrative sphere and falls under the Mayoral

Committee. Only executive management and senior City of Cape Town officials form part of the Transversal Management Structure (City of Cape Town, 2015a).

The Transversal Management Structure is split into an Economic and Social Cluster. The Facilities Optimisation Working Group falls under the Economic Cluster. The Facilities Optimisation Working Group is tasked with looking at the City's assets from a Transversal Management perspective, as well as implementing some of the IBM (2013) report findings regarding the City of Cape Town's assets. The City of Cape Town's energy efficiency work within its own operations falls under the Facilities Optimisation Working Group, and has been presented at this Working Group. Chapter 5 illustrates the business model presented to the Facilities Optimisation Working Group on ways in which the City can implement and gain substantial savings from energy efficiency within its own operations.

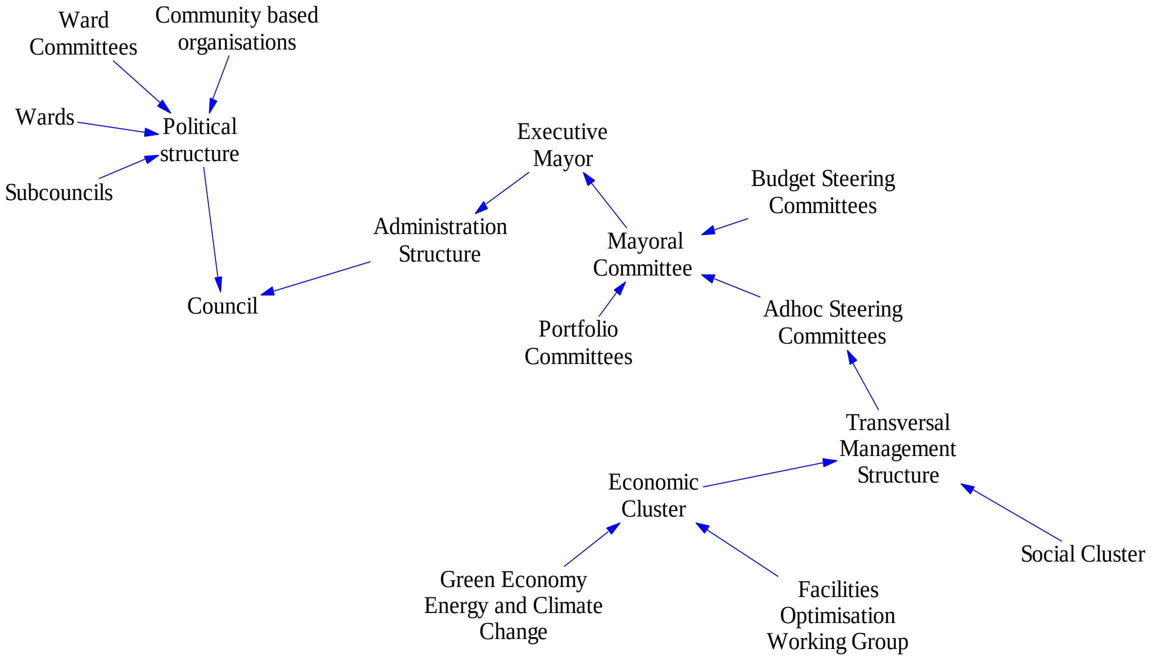

Figure 4.12: Diagrammatic illustration of Council and how the transversal management system fits into the structure

Source: (City of Cape Town, 2015b)

4.10 Business Model for City of Cape Town energy efficiency programmes

The building blocks of this business model, which aims to institutionalise energy efficiency within the City of Cape Town's internal operations, are best illustrated in Figure 4.13. The business model developed for this study, does not consider the traditional business sector definition. It is not just a financial mechanism, which is developed. In the context of a municipality, a business model is defined as a business process that maps out the steps required to implement energy efficiency in a sustainable manner. This business model comprises a policy layer, organisational placing or setting layer and finally energy targets and departmental business plans. These three aspects or combined 'layers' are required to ensure that energy efficiency within the City of Cape Town's own operations is institutionalised and becomes the new 'business as usual'.

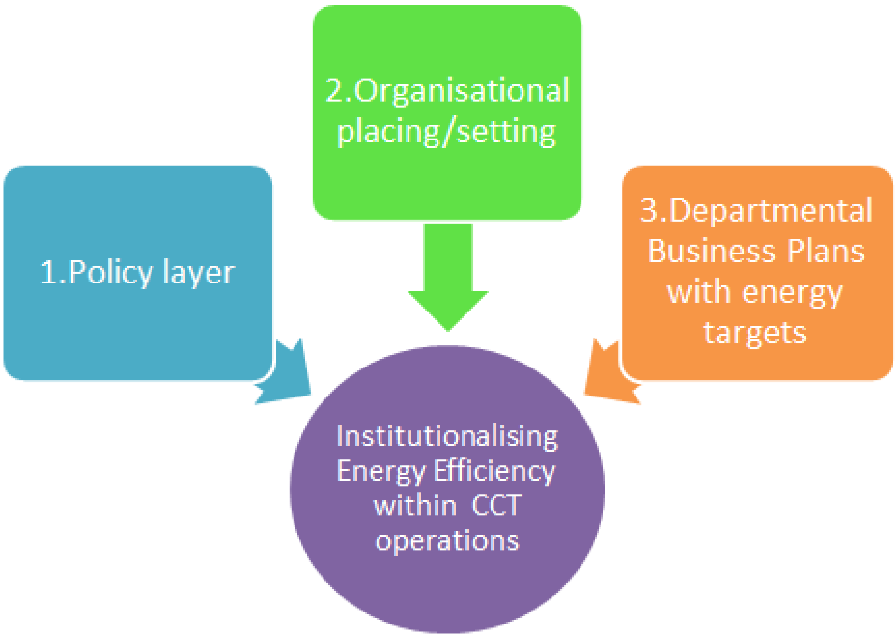

Figure 4.13: Illustration depicting the core building blocks of the business model developed

4.11 Institutional framework and policy

The City of Cape Town has an Energy and Climate Change Strategy (City of Cape Town, 2006) and Energy and Climate Change Action Plan (City of Cape Town, 2011). These strategies and policies provide the overarching policy framework stipulating why the city needs to secure its energy in a sustainable manner. The Energy and Climate Change Action Plan (City of Cape Town, 2011) sets a target for the city's internal operations to reduce its energy consumption. These policies and strategies have enabled the implementation of various energy efficiency and renewable energy programmes through the Energy and Climate Action Plan the Environmental Resource Management Department has been able to apply for various grant funding to initiate and implement energy efficiency programmes, but there remains a policy gap when it comes to continuation, consolidation and mass roll out by all city departments. In order for departments to drive and embed energy efficiency and renewable energy as part of their normal business plan, they require specific policy that clearly defines roles and responsibilities. The Internal Energy Management Protocol was developed with the specific aim of clearly defining the department's roles and responsibilities around energy. In 2013, a draft Internal Energy Management Protocol was developed by the Environmental Resource Management Department, Energy and Climate Change Unit.

Part of this dissertation study required understanding of the most suitable area for this policy to be implemented within the organisation. A key challenge with the work implemented by the Environmental Resource Management Department is to ensure that departments buy into the process and see this policy as part of their operational mandate. This policy should not be viewed as another "green policy" and be seen solely as the Environmental Department's responsibility. Buildings and facilities within the City of Cape Town are currently managed in a very fragmented manner

Property Management department has been mandated with creating the necessary policy framework in order to ensure a co-ordinated and structured approach in the manner in which all departments in the City are managing facilities or buildings. Property Management department has developed an Immovable Property Asset Management Policy (City of Cape Town, 2014). It is therefore the best suited to adopt and finalise the draft Internal Energy Management Protocol with the Property Management Department. The draft Internal Energy Management Protocol will become an addendum of the Immovable Property Asset Management Policy (City of Cape Town, 2014).

Finding the correct place within the organisation is a fundamental component to understand and identify. Making the Internal Energy Management Protocol part of the Immovable Property Asset Management Policy (City of Cape Town, 2014), will build relationships and re-enforce the goals of the Immovable Property Asset Management Policy (City of Cape Town, 2014). It breaks the traditional silo mentality within which City of Cape Town and Government departments traditionally operate. It is in line with the City of Cape Town's future vision of creating a transversal manner in which City of Cape Town departments will operate. The Internal Energy Management Protocol aims to achieve the following:

- Develop a central guiding protocol (standard operating procedures) for City of Cape Town Departments to follow when implementing energy efficiency and ensure that renewable energy initiatives and are not implemented on an ad hoc basis;
- Develop an overall energy data management and reporting system to assist in better reporting on Energy Climate Action Plan targets;
- Define roles and responsibilities;
- Follow a uniform process in prioritising, monitoring and evaluating energy efficiency initiatives;
- Make departments aware of their energy consumption and expenditure with the aim of better managing their consumption;
- Develop Key Performance Indicators for energy consumption for each department; and
- Ensure departments receive proper assistance and support to implement energy efficiency initiatives.

The City of Cape Town has created a transversal management steering committee to initiate the process of collaboration between departments in order to improve planning and delivery of services. This transversal management structure comes at an opportune time as this structure supports both the Immovable Property Asset Management Policy and Internal Energy Management Protocol goals. In order to operationalise the Internal Energy Management Protocol, a resource efficiency sub working group has been suggested within the Facilities Optimisation Work Group.

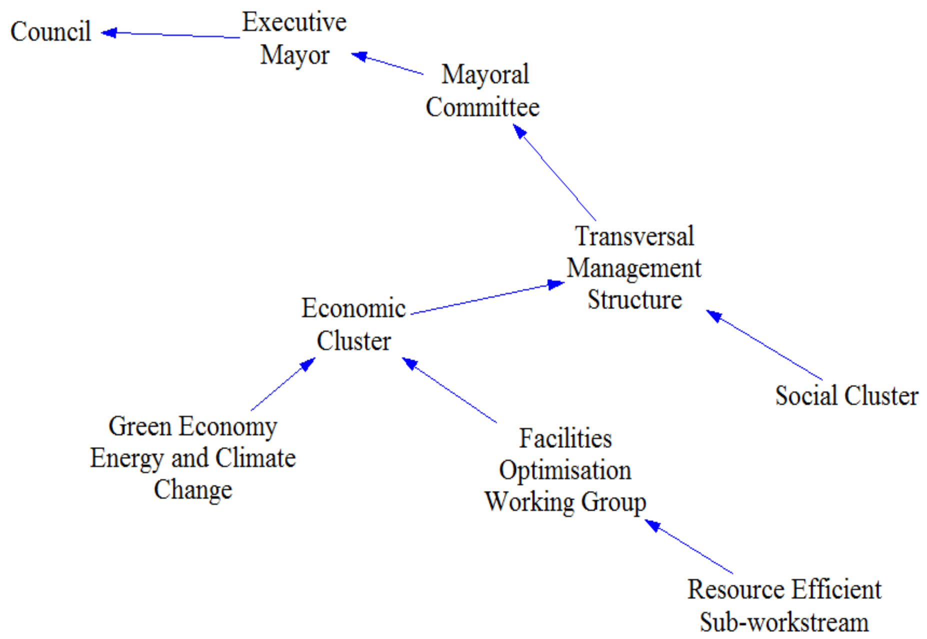

Figure 4.14: Diagrammatic illustration of organisational process to support resource efficiency within City operations

Figure 4.14 gives a diagrammatic illustration of the way in which resource efficiency fits within the organisational framework. This sub-work stream reports on a quarterly basis to the Facilities Optimisation Work Group. All departments select a senior representative to form part of the sub-work group. This sub-work group ensures accountability, reviews departmental resource efficiency business plans, assists in raising challenges at a high level within the organisation, creates visibility for these programmes and develops staff skills through appropriate training. This sub-work group will take an incremental approach, starting with a selection of departments as a pilot. Specialised Technical Services and Sports, Recreation and Amenities have been selected as the two pilot departments for which Environmental Resource Management Department will develop business plans.

The resource efficient sub working group will concentrate on the following, as illustrated in Figure 4.15. Assessing the past energy efficiency programmes which Environmental Resource Management Department has been actively driving and assisting departments to implement since 2003. Assesing whether departments have changed their business process to stock the new efficiency technology, results of this is presented in section 5.5 on page 135, indicated that departments responsible for City of Cape Town buildings and facilities do not keep up with changes and developments in technology, i.e., they do not upgrade their store stock items. Material goods items which are regularly used by City of Cape Town Departments are required to be stocked within the City of Cape Town's store. These items are known as store stock items. The procurement system for these items needs to be adapted to support resource efficiency. An integrated data management system is required for all resources consumed within the City of Cape Town's internal operations. The need for a standardised policy to ensure everyone is working towards the same goals is required, hence the development of the Internal Energy Management Protocol.

It has been proposed that the Environmental Resource Management Department bethe chair of this resource efficiency sub working group, as it has developed the necessary capacity and has been driving most of the energy efficiency programmes within the City of Cape Town's internal operations to date. The Environmental Resource Management Department is required to play a facilitating role and assist departments to build their own internal capacity in order to make this new working structure possible. The reason for a resource efficiency sub working group is that the City of Cape Town understands that there remains a huge opportunity to save on all resources. The past 13 years has seen a particular focus and drive of energy efficiency programmes within the City of Cape Town's buildings. This is due to the Environmental Resource Management Department, which had this capacity and skill and could drive these energy efficiency programmes. This sub working group will become the platform to hold all City of Cape Town departments accountable for all resources going forward.

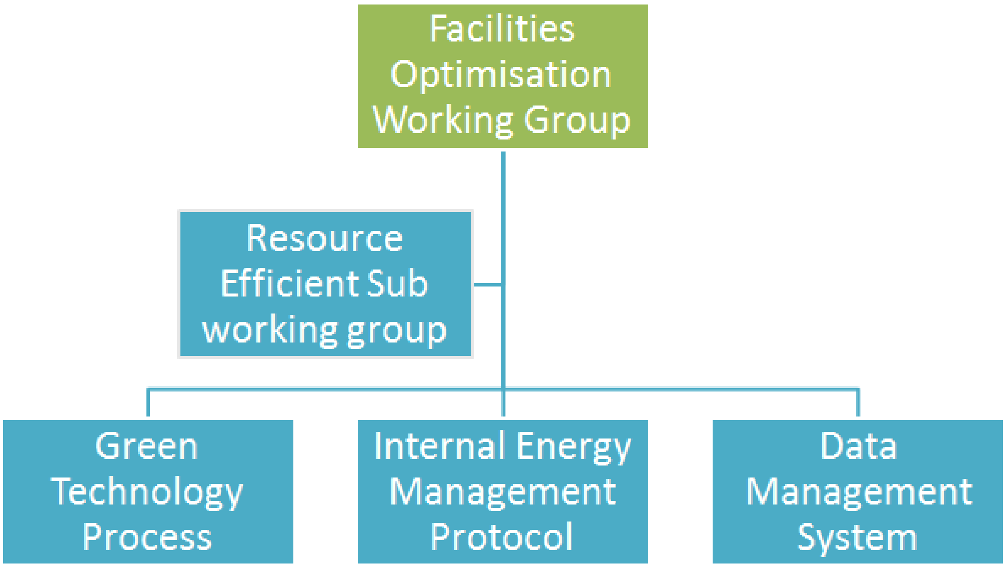

Figure 4.15: Diagrammatic illustration of the themes under the resource efficient sub-working group

a) Green Technology Process

A core role of this sub-working group is to ensure that departments are held accountable for implementing the Internal Energy Management Protocol, but most importantly, to assist departments to keep up with advancement and changes in technology. The necessary training is required to ensure that all staff responsible for managing equipment is trained. Green Procurement falls outside the scope of this study, although it plays an integral part in supporting the procurement of goods and services, which are resource efficient. Work on greening the City of Cape Town's supply chain management system is underway. Figure 4.16 illustrates the key focus areas under the Green Technology Process theme.

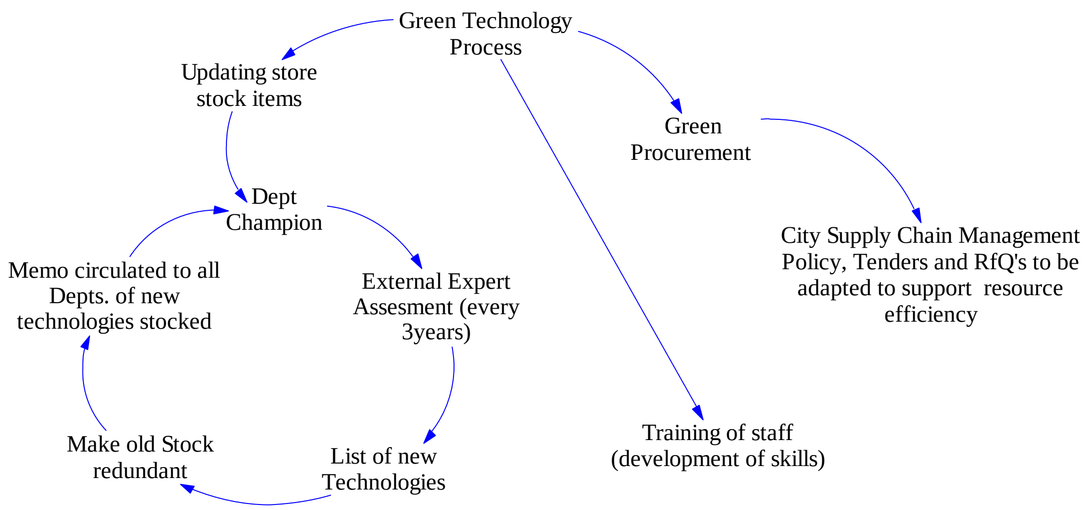

Figure 4.16: Diagrammatic illustration of Green Technology process key focus areas

b) Data Management System

Data remains one of the most integral parts of this business model. Data within the buildings and facility category of the City of Cape Town is currently poorly recorded and collected. The Environmental Resource Management Department commissioned a study in collaboration with Specialised Technical Services in 2007, with the aim of ranking the Specialised Technical Services ninety large corporate administrative buildings with regards to their energy consumption. This study provided key insight into the challenges in accessing electricity consumption data, billing data and general information on these buildings. All of this information and data is hosted either on the City of Cape Town's Systems Applications Products or on a spreadsheet kept by individual building managers. The key lesson learnt during this study is that, when the building energy data is not stored in a centralised system, acquiring this scattered data is onerous. Most of the buildings are not metered and most the City of Cape Town facilities have more than one building, but the meter does not measure the entire facility. This was another key lesson learnt during the smart metering programme. These challenges all indicated that an integrated data management system, which is easily accessible and stores data in a central location is needed.

In conclusion, it is evident that an integrated data management system is required to monitor all resources used within the City of Cape Town's buildings and facilities.

Starting with an Energy Data Management System but ensuring that the system can accommodate all other resources as time progress.

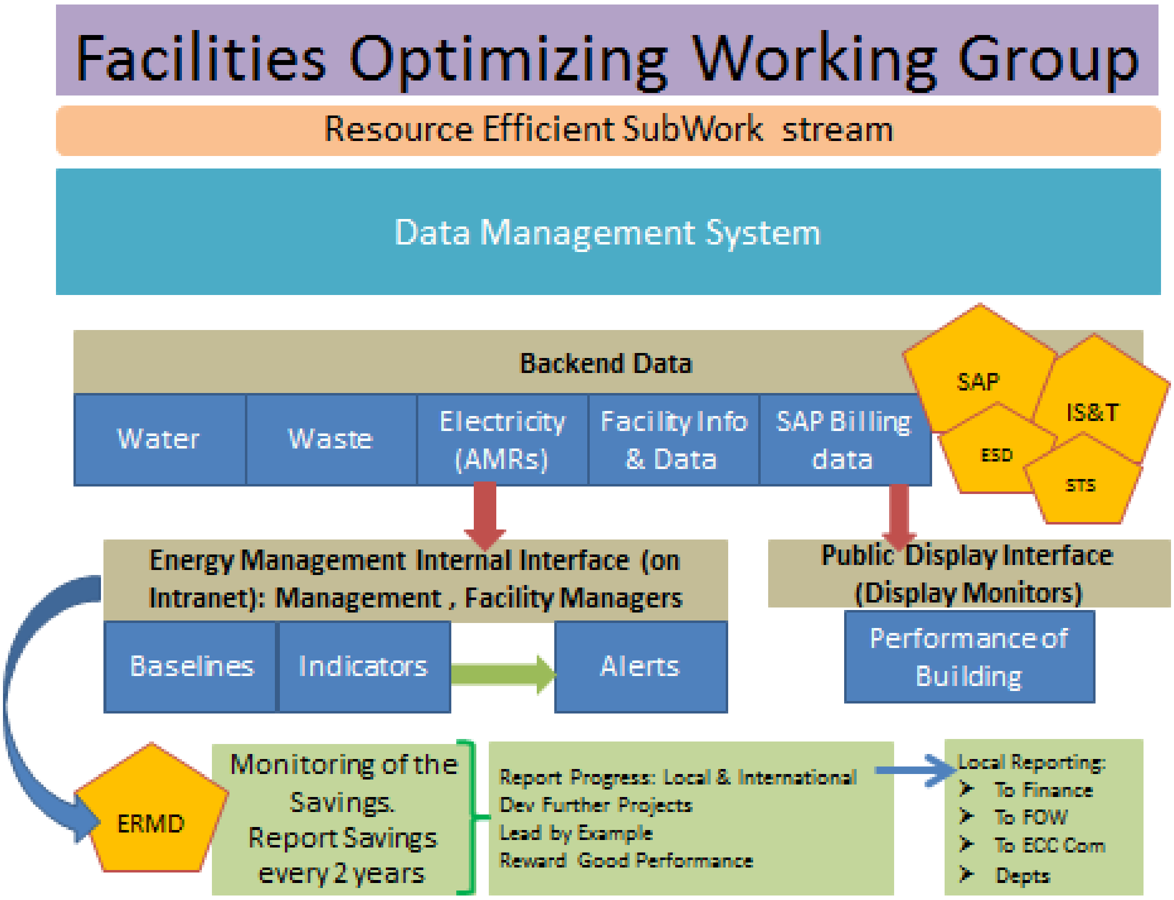

Figure 4.17: Diagrammatic illustration of Data Management System to be developed

Source: City of Cape Town (2014)

An energy data management system project was initiated in 2016. This project highlighted the complexity of developing a centralised data management system. The key challenge has been that there are a number of different departments involved, which requires creating a centralised data management system. A centralised data management system merely refers to consolidating the various energy data into one central system and where end users can access the data from a decentralised manner but data is easily accessible. In order to develop this centralised system, the Information Systems and Technology Department is required to ensure that the City of Cape Town network can be used to store and send this data to a central data management system. The City of Cape Town, however, has a fragmented network, and the electricity services department has their own server to collect and store data. Furthermore, Specialised Technical Services has their own server to manage their building information. Establishing support and approval from the Information Systems and Technology Department has been instrumental to facilitating access to the energy data management system created on the Specialised Technical Services Department server, by using their broadband network in order to ensure that information is accessible from any City of Cape Town facility or building.

Figure 4.17 is a diagrammatic illustration of the data system to be developed. The grey blocks represent the back end data and front end data system. The red arrows represent the path used to develop the centralised data system known as the front end system. The orange pentagon shapes represent the various departments involved and details where they are involved. The back-end data system has been designed to ensure that all the various information and data is collected and sent to the front end system, where this information is presented in an easy to understand and user-friendly manner.

The front-end system comprises two displays, one for the internal City of Cape Town users such as facility managers and the City of Cape Town management structure, and another public display interface, which only shows the performance of the building to the public. Each of these front-end displays has specific information and data that conveys necessary information on the performance of the building to the end user. The Internal interface will have a baseline, indicators and alerts developed, which will assist facility managers in managing their building more efficiently, and update management on the progress and performance of energy consumption. The Environmental Resource Management department has been collecting and collating this data manually in the past in order to meet its reporting requirements both locally and at internal reporting platforms. The energy data management system has been built and is currently in the testing phase.

This data management system has been developed by focusing on the electricity data available. This system has been designed to accommodate, present and display all other resource information such as water and fuel consumption. Developing this energy data management system forms the measurement and verification tool of the Internal Energy Management Protocol.

The data from the energy management system was used to develop baselines, set targets and train building facility managers on how to read and use the data to manage their buildings consumption more effectively. This energy data management system was used to develop further projects and improve strategies on energy efficiency within City of Cape Town buildings and facilities, and will further assist the City of Cape Town to continue to lead by example through effective energy management of its facilities and buildings.

c) Internal Energy Management Protocol process

The Internal Energy Management Protocol can be defined as a policy with the aim of becoming a standard operating procedure, which will assist and guide departments on ways of implementing energy efficiency and renewable energy within the City of Cape Town buildings and facilities. The Internal Energy Management Protocol comprises the following process and is best explained through Figure 4.18.

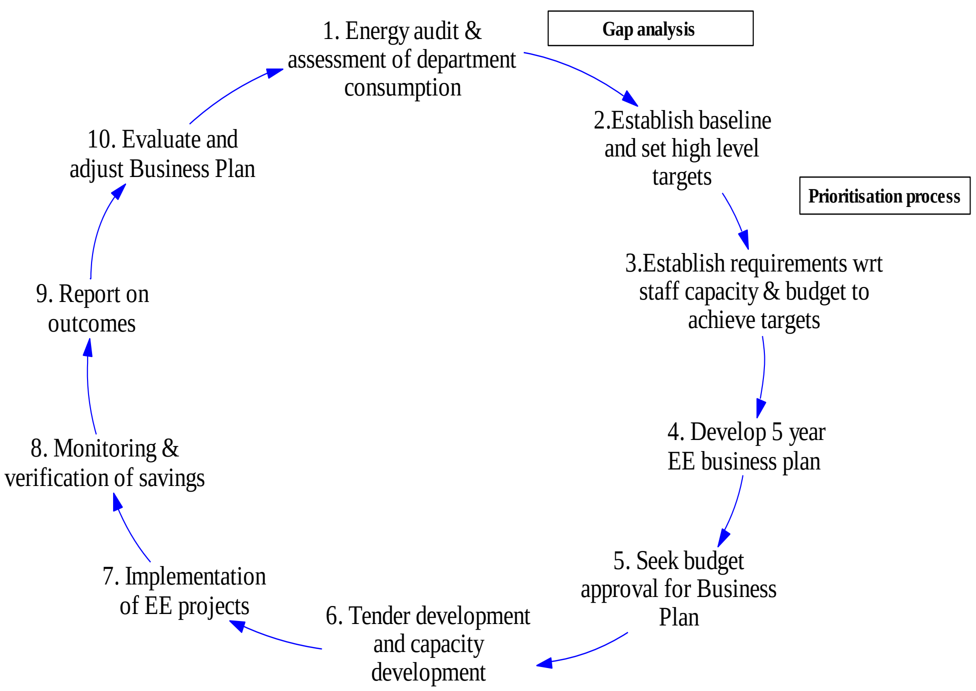

Figure 4.18: Graphical illustration of IEMP process

The first step departments have to take is to conduct an energy audit and establish their energy consumption. This step is called a gap analysis. Once their consumption has been tracked, a baseline can be established and high level targets for the department can be set. This step is called a prioritisation process which would assist departments to focus on easily implemented changes. The next step is to establish the capacity and budget requirements needed in order to achieve these targets, and then the development of a five year business plan. Approval from each department and Council of the business plan is required. Upon the approval of the five year business plan, departments can then proceed to develop tenders and identifying key staff to attend capacity development training, such as fundamental energy management training. Step 7 is the implementation of these projects. Upon completion of the projects, monitoring and verification of the savings will be required. This function will be managed and executed by the Environmental Resource Management Department, which has the mandate to achieve the targets set in the Energy and Climate Action plan but also has the necessary knowledge and experience to guide departments through the processes, and is the chair of the resource efficiency sub working group. Step 8 requires departments to report on the outcomes of the project and highlight the savings, challenges, lessons learnt and improvements to the management of their business plan. Step 10 allows departments to reflect on and evaluate their business plans. This cycle is re-iterative which is why it is represented in a circle. Departments continue with this cycle until they have achieved their targets and continue to establish new targets and develop updated five year business plans.

The Internal Energy Management Protocol illustrated in Figure 4.18 is the business model that was presented to the Facilities Optimisation Working Group in October 2015. The Facilities Optimisation Working Group supported the business model and tasked the Environmental Resource Management Department to pilot this business model (see Annexure B), as part of the pilot phase of implementing the Internal Energy Management Protocol process. The Environmental Resource Management Department has been tasked with assisting departments to conduct a gap analysis, enter the prioritisation phase and develop five year business plans. Through the establishment of the resource efficiency sub working group, the Environmental Resource Management Department has been tasked with implementing the Internal

Energy Management Protocol process with two pilot departments, namely, Specialised Technical Services and Sport and Recreation Amenities. Approval of the business plans for both departments was presented to the Facilities Optimisation Working Group. The Facilities Optimisation Working Group will have the mandate to seek Council approval for these business plans. Once Council's approval has been received, departments will be held accountable for achieving the targets set against the five year business plans developed. This process illustrates the accountability and support to ensure that energy efficiency within the City of Cape Town's internal operations is achieved.

4.12 The development of departmental energy targets and business plans

In order to complete this business model, a process of developing business plans and the setting of energy targets for departments was required. This layer required a technical process to be developed. The setting of departmental targets assists in defining a goal and allows for specific actions to be identified which then become integrated into the business plan. These implementation actions, once identified, allow for the estimation of cost, which completes the departmental business. This process allows for clear accountability and provides each department with a clear plan on achieving their targets.

4.13 Summary

Momentum has been built over the years through the implementation of energy efficiency projects across all key departments within the City of Cape Town's internal operations. It is evident that having a dedicated team driving and facilitating energy and climate change related matters, has enabled a coordinated approach to implementing energy efficiency within the City of Cape Town's internal operations. The foundation for future projects has been laid, with key lessons learnt from projects being implemented. The City of Cape Town's executive management and policy framework now creates in ideal environment for institutionalising energy efficiency within the City of Cape Town's own operations. The following chapter aims to present the results achieved by the energy efficiency programmes as implemented by the Electricity Services Department, Traffic Signal Department and Environmental Resource Management Department, in collaboration with Corporate Services, Specialised Technical Services Department.

5 Results – City of Cape Town's internal energy efficiency programmes

This chapter presents the results of the energy efficiency programmes, as implemented within the internal operations of the City of Cape Town for the period 2009 until 2014. The results focus on programmes implemented by the Electricity Services Department, Traffic Signal Department and Specialised Technical Services Department. The results are presented with the aim of answering research questions one and two of this study.

5.1 Overview of the results of the internal energy efficiency programme

Figure 5.1 illustrates the electricity savings achieved from the projects implemented between 2009 and 2014. The future savings, as, projected from 2014 to 2019 are based on planned projects to be implemented during this period. This data was provided by the Environmental Resource Management Department. The street and traffic lighting projects yielded the highest savings, while the buildings savings increases from 2014 to 2019 due to additional projects completed in 2016 increasing electricity savings.

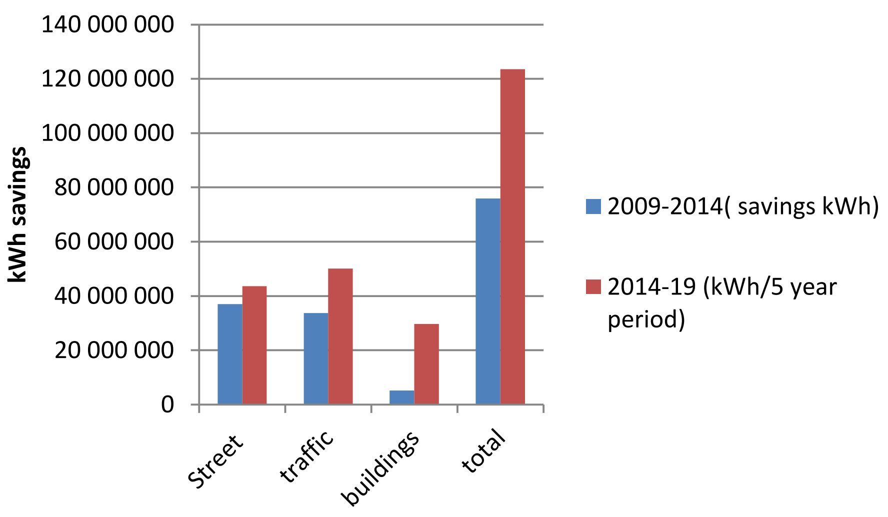

Figure 5.1: Electricity savings overview from City operations projects

The financial savings are illustrated in Figure 5.2. The financial savings are based on electricity tarrifs used by the Electricity Department. The Electricity Department purchases electricity from Eskom. Electricity deparment charges internal departments for electricity used. An annual saving of R18 million is achieved, with a total investment of R164 million until 2016, resulting in a simple payback period of 8 years. The City of Cape Town's finance department advised the Environmental Resource Management Department that a payback period of ten years and lower is considered to be a good financial return on investment. The energy efficiency projects implemented up until 2016 proves that making the City of Cape Town's own operations energy efficient would save the City of Cape Town money and yield good financial returns.

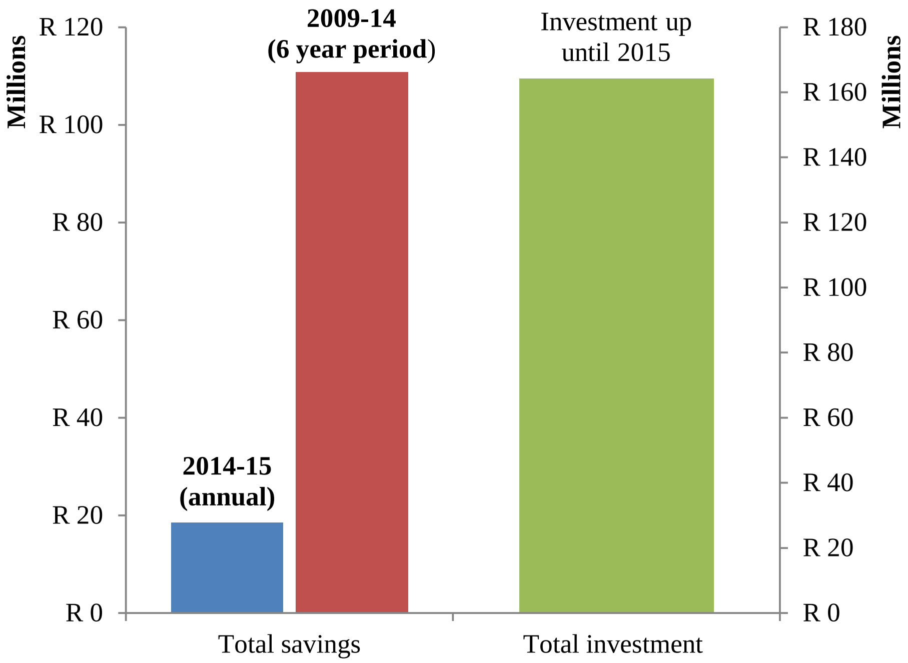

Figure 5.2: Financial savings overview from City operations projects

The benefits of energy efficiency projects is that savings accumulate and with the guaranteed steep electricity price increases the country faces, the financial savings are deemed to increase substantially year on year, as illustrated in Figure 5.3.

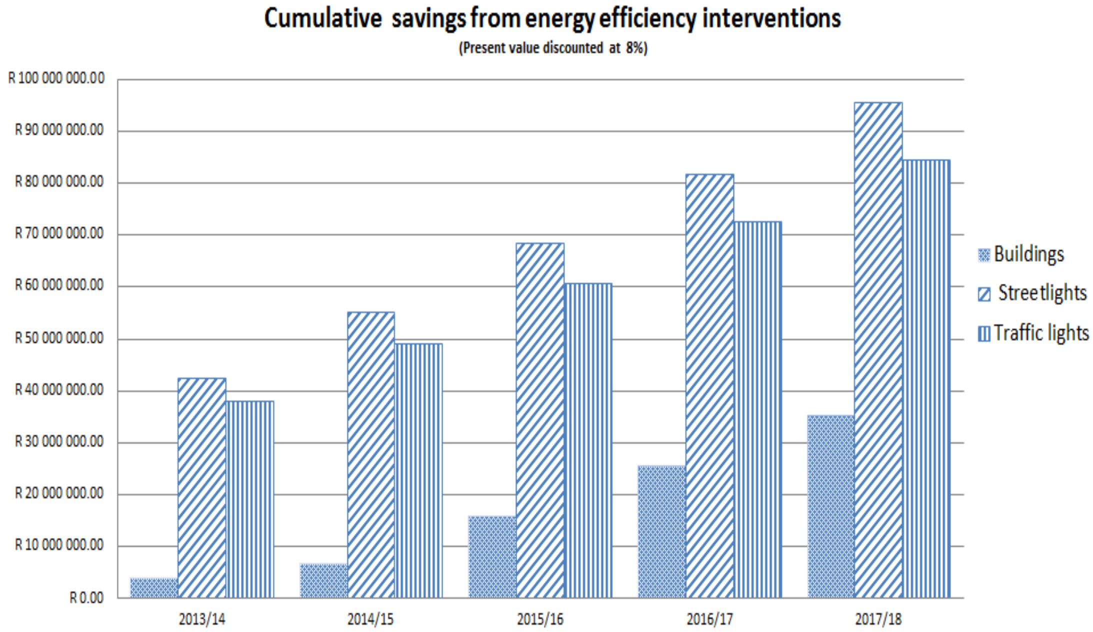

Figure 5.3: Financial savings from electricity savings projects into the future

Figure 5.3 illustrates the increase in financial savings from the implemented energy efficiency projects. A discount rate of 8% was used as advised by our Finance Department and a conservative electricity price increase of 10% was projected based on projected electricity price increased by Eskom bulk purchases given by the Electrictiy Services Department. A total saving of a R84 million in the 2013 financial year will increase by two and a half times, to R214 million in 2017. What this illustrates is that every opportunity missed to implement an energy efficiency project within the municipal infrastructure is a wasted opportunity, as a higher return on financial savings will be achieved the sooner projects are implemented.

5.2 Savings from street lighting electricity efficiency programme

A 10% saving was achieved against the 2007 baseline for street lights electricity consumption (91 751 944 kWh) for the period 2007 up until 2015 (Cape Town, 2015a). The data and results for street lighting efficiency programme can be found in Annexure B. It is important to state that the Energy Efficiency Demand Side Management funds were used to procure all fittings as well as cover the installation cost of the project. The financial and electricity reduction in savings for the street lighting project for the period 2009 up until 2015 is illustrated in Table 5.1.

Table 5.1: Cumulative savings for street lighting projec

Savings	**Total cumulative savings for the period 2009/2010 to 2014/15**
Total investment (Rands)	R59 491 510
Financial Saving (Rands)	R55 103 234
Cumulative saving kWh	36 962 760
Cumulative Carbon (kg)	36 593 132
Payback period (years)	7

The savings achieved through electricity reduction are well documented and reported in energy efficiency programmes. What is not verified and reviewed is if the savings will be maintained, and if the necessary operational processes have been adapted to ensure that long term savings will be achieved.

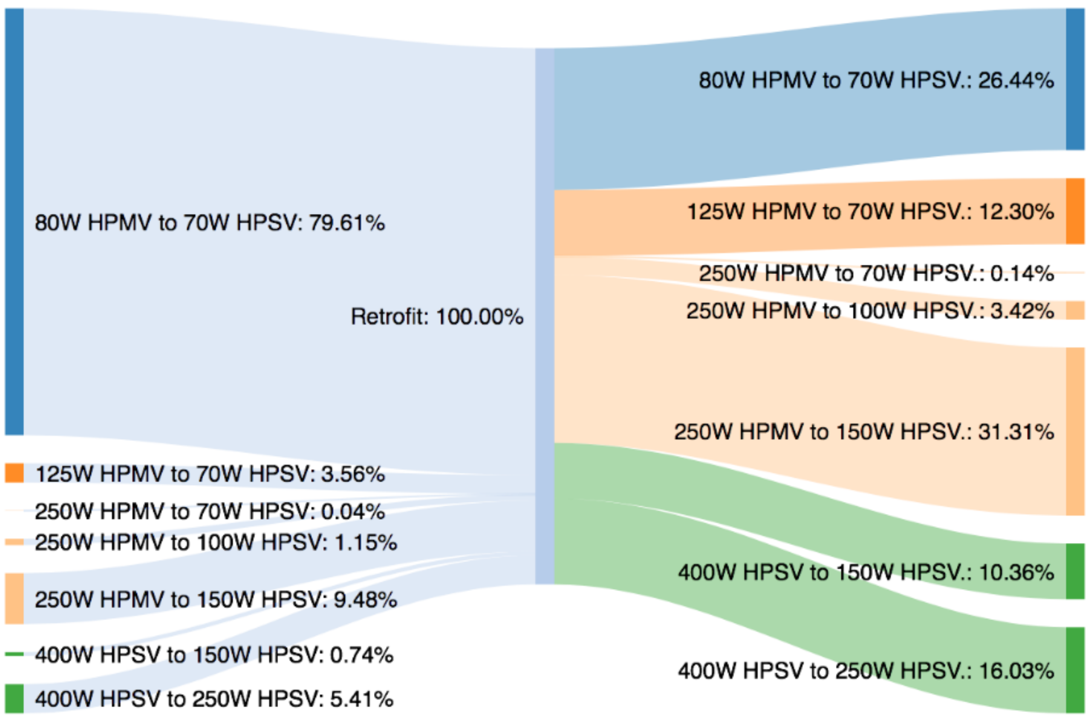

Figure 5.4: Phase 1 - street lighting energy efficiency retrofit results

Source: Cape Town (2015a)

Figure 5.4**Error! Reference source not found.** illustrates the street lighting retrofits implemented during the phase 1 Energy Efficiency Demand Side Management programme from 2009 up until 2012. From Figure 5.4 it can be seen that a very conservative view was taken from a technological perspective. No new technological change was introduced. An efficiency gain was achieved through using the same inefficient technology, but by reducing the wattage. The predominant street light retrofits occurred by changing the 80 W to 70 W high pressure sodium vapour street lights. The highest savings resulted from the 250 W high pressure mercury vapour retrofits to high pressure sodium vapour street lights, which is illustrated in Figure 5.4. Monitoring and Verification by external experts confirmed a sixty seven percent electricity reduction achieved by this programme. The Energy Efficiency Demand Side Management phase 1 conditions set by the Department of Energy were very relaxed, focusing mainly on the efficiency gains to be achieved and not making it part of the programme to promote and enforce technological change from an energy efficiency perspective (RSA, 2009).

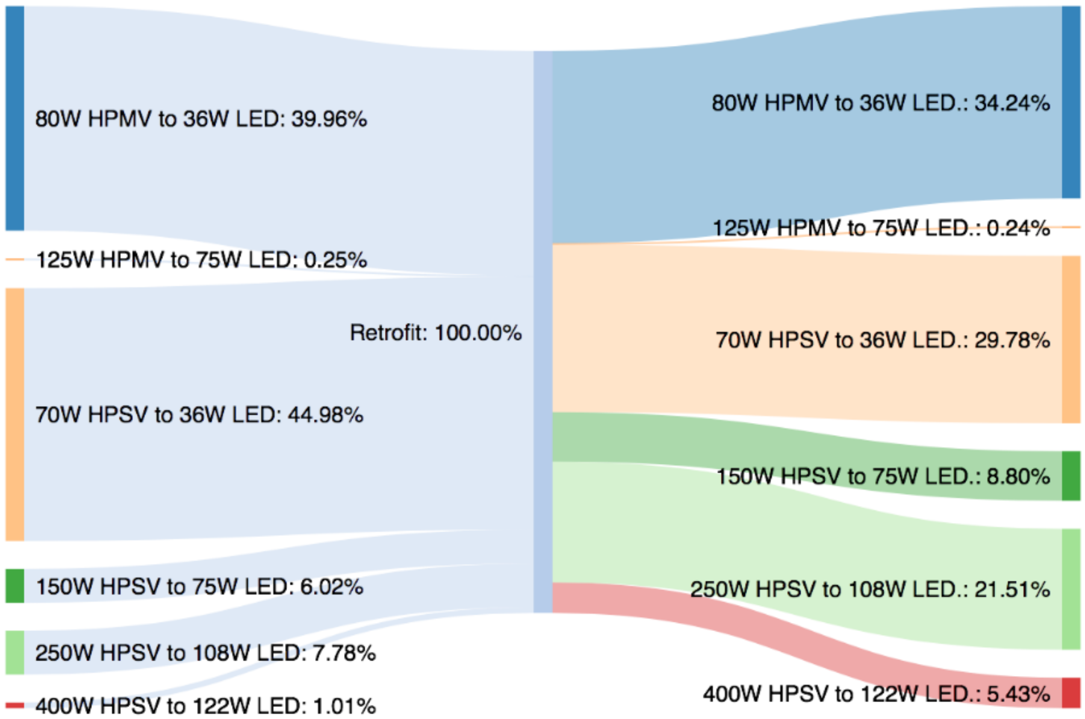

Figure 5.5: Phase 2 - street lighting energy efficiency retrofit results

Source: Cape Town (2015a)

Figure 5.5 illustrates phase 2 of the street lighting energy efficiency retrofit results which took place in 2014 to 2015. Phase 2 of the street lighting energy efficiency retrofit saw a technology change being implemented whereby inefficient street lights, namely: high pressure sodium vapour, and high pressure mercury vapour, were retrofitted with light emitting diode technology. Of the 80 to 70W high pressure sodium vapour lights, 1,354 were retrofitted, which yielded the highest financial savings. A hundred and twenty four of the 250 W high pressure sodium vapour street lights were retrofitted to a 108 W light emitting diode street light, which resulted in the second highest financial savings achieved. A higher saving is achieved by retrofitting the high wattage street lights to lower wattage street lights, however, over 80% of the streetlights are made up of 70W and 80W high pressure sodium vapour street lights. The retrofitting of street lights to energy efficient street lights remains a priority as there are huge savings which can still be achieved.

The financial benefits of a reduction in electricity consumption has been proven by the results of the energy efficiency in street lights implementation. Through the participation of the electricity services department in the Energy Efficiency Demand Side Management programme, 17% of the City of Cape Town street lights have been retrofitted to energy efficient street lightsince 2009 up until 2015.

5.3 Savings from traffic lighting electricity efficiency programme

The financial and carbon savings are illustrated in Table 5.2. The traffic lighting energy efficiency programme yielded good results, and within a four-year payback period achieved eighty percent electricity saving, which was verified by monitoring and verification experts.

Table 5.2: Cumulative savings for traffic lighting project

Savings	**Total cumulative savings for the period 2009/2010 to 2014/15**
Total investment (Rands)	R29 125 473
Financial Saving (Rands)	R48 986 276
Cumulative saving kWh	33 767 776
Cumulative Carbon (kg)	33 430 098
Payback period (years)	4

Table 5.2 illustrates the savings achieved from the traffic lighting energy efficiency project. The traffic lights consumed a total of 10 110 833 kWh during 2007 (this is the baseline) after the retrofit in 2012 the total electricity consumption for traffic lights resulted in 1 668 889 kWh. An 83% savings off the 2007 baseline was achieved through the retrofit.

Table 5.3: Traffic lighting retrofit project part of Energy Efficiency Demand Side Management phase 1 programme

Lighting technology intervention	**Year completed**	**Current light (W)**	**Retrofit (W)**	**Total no of Lights**	**Savings kWh per annum**	**% Saving off 2007 baseline**
	2010	**75**	**8**	**21 280**	**4 220 972**	**83**
Incandescent to LED	**2012**	**75**	**8**	**21 053**	**4 220 972**	
	Total			**42 333**	**8 441 944**	

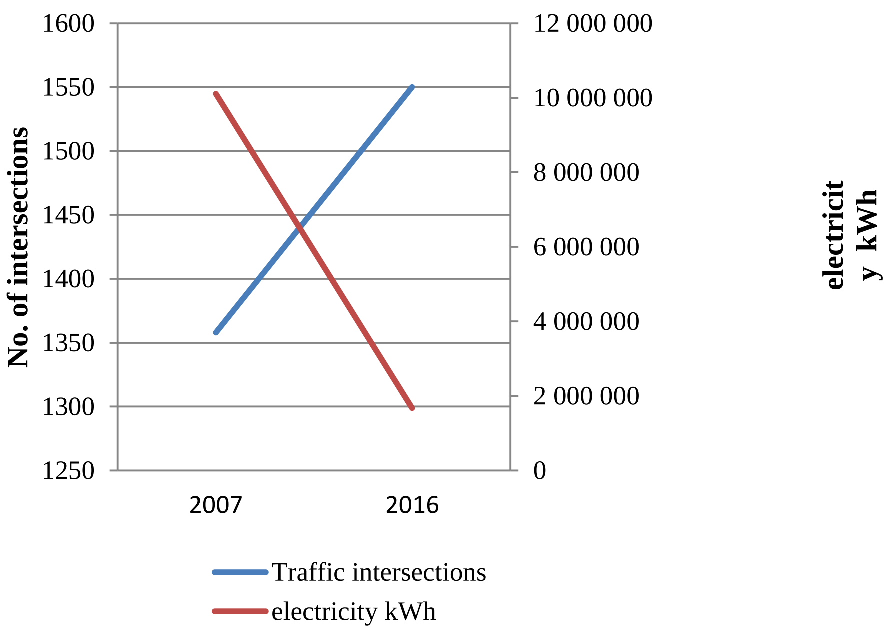

Figure 5.6: Graphical illustration of decoupling from increased services and reduction in consumption from traffic lighting project

The savings from electricity efficiency projects are the obvious benefits associated with these interventions. Figure 5.6 is a graphical illustration of the impact of decoupling at a services level. As the City of Cape Town continues to develop it will be required to increase and expand its services. The number of traffic lights has increased from 1 350 in 2007 consuming a total of 10 110 833 kWh, to 1 550 in 2016, consuming a total of 2 000 000 kWh. Electricity consumption has been reduced by eighty three percent through the LED traffic lighting intervention, even as the number of traffic intersections have increased. This is a good example of the added benefits of resource efficiency and decoupling (Schaffartzik, Mayer, Gingrich, Eisenmenger, Loy, *et al.*, 2014; West, Schandl, Krausmann, Kovanda & Hak, 2014).

5.4 Savings from building energy efficiency programme

Figure 5.7, Figure 5.9 and Figure 5.11 illustrate each building's electricity consumption profile before the energy efficiency and renewable energy retrofit. The baseline before the energy efficiency retrofits allows one to see the impact of the retrofit implemented and the change in consumption profiles between 2014 and 2015. A second baseline was developed to show the impact of the renewable energy intervention implemented at each building. This is depicted by the blue intermitted line. Following the 2015 consumption data for Figure 5.8, Figure 5.12 allows one to see when the renewable energy system came into effect, as the consumption profile is below the baseline showing the impact of the renewable energy implementation.

Figure 5.8, Figure 5.10 and Figure 5.12, illustrate the impact of the energy efficiency and the renewable energy interventions for each building. All three buildings received a complete energy efficiency retrofit of their lighting with sensors installed. In Figure 5.7 we can see that Gallows Hill building received a 10kWp PV system. The renewable energy intervention only resulted in a 14 937 kWh/annum supply of renewable energy, which is 2% of the total building's electricity supply, while the energy efficiency intervention yielded an electricity reduction of 107 076 kWh which translates into an 18% saving on the overall electricity consumption of Gallows Hill building. Figure 5.10, showing the Royal Ascot building, which received a 20kWp PV system resulting in a 22 976 kWh/annum of electricity generated which translate to a 7% supply of renewable. An electricity saving of 76 968 kWh was achieved from the energy efficiency intervention for Royal Ascot. Figure 5.12, depicting the Omni Forum building, received a 60kWp PV system which resulted in the generation of 61 346 kWh/annum of electricity from the renewable energy system. This resulted in 20% of the electricity supply for the building coming from a renewable energy source. The energy efficiency interventions only resulted in 57 576 kWh/annum of electricity saved, resulting in a 16% overall electricity consumption reduction achieved.

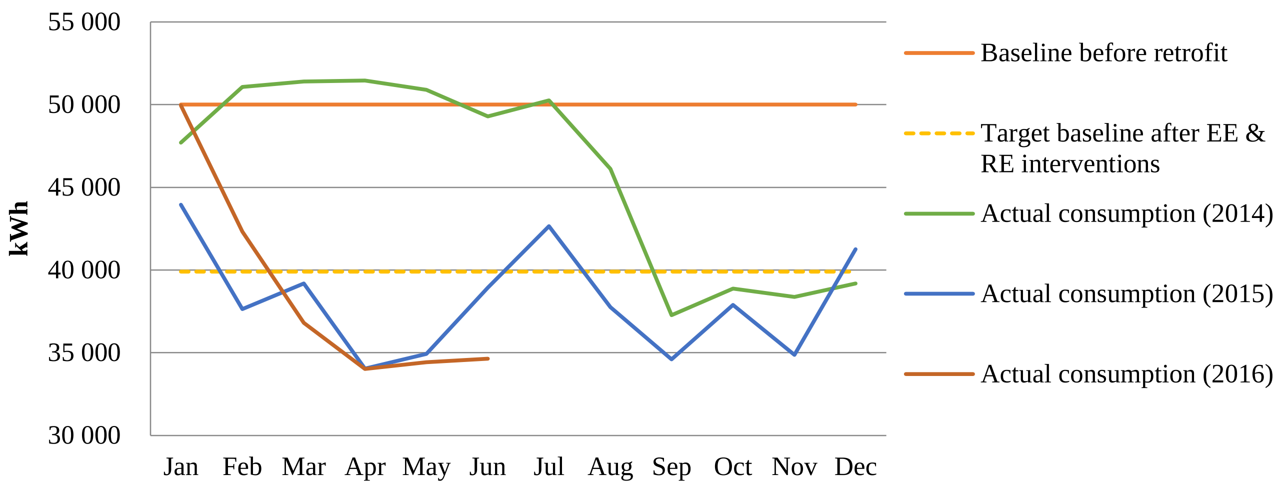

Figure 5.7: Gallows Hill baseline and electricity consumption profile

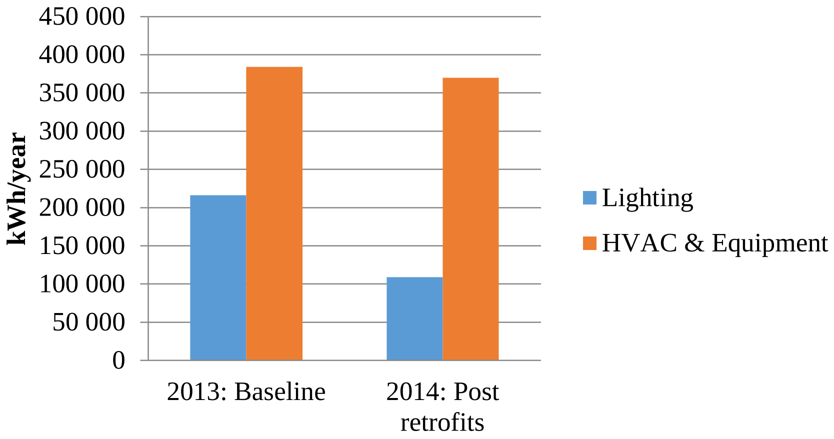

Figure 5.8: Gallows Hill baseline before EE & RE interventions and impact of EE & RE interventions

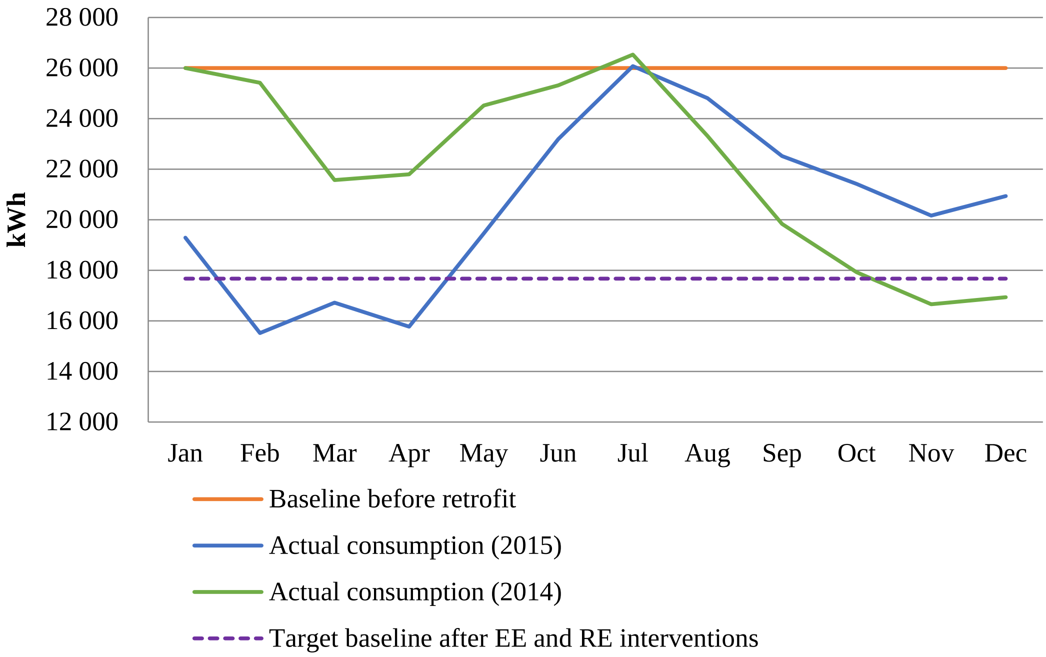

Figure 5.9: Royal Ascot administrative building retrofit baseline and electricity profile

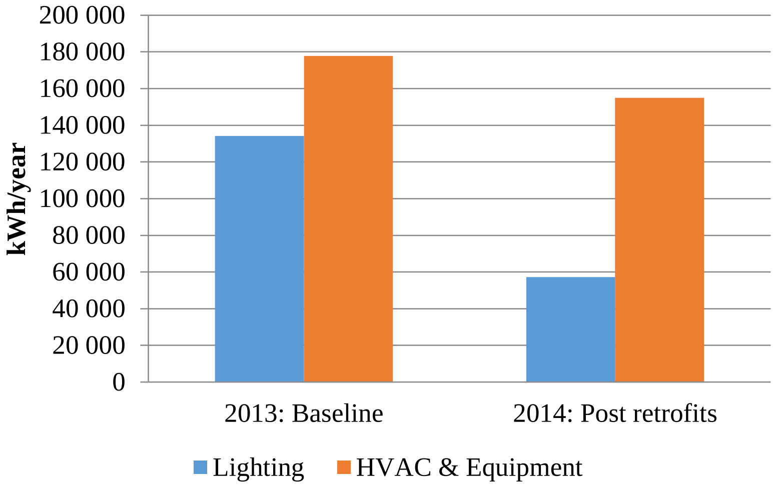

Figure 5.10: Royal Ascot administrative building retrofit project before EE & RE interventions and impact of EE & RE interventions

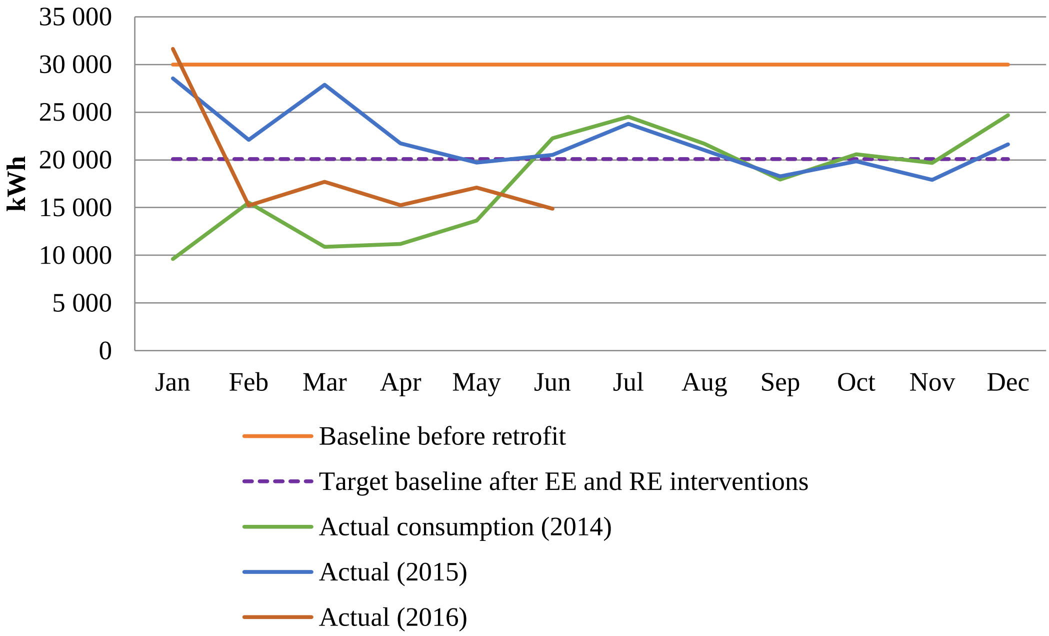

Figure 5.11: Omni Forum retrofit project baseline and electricity profile

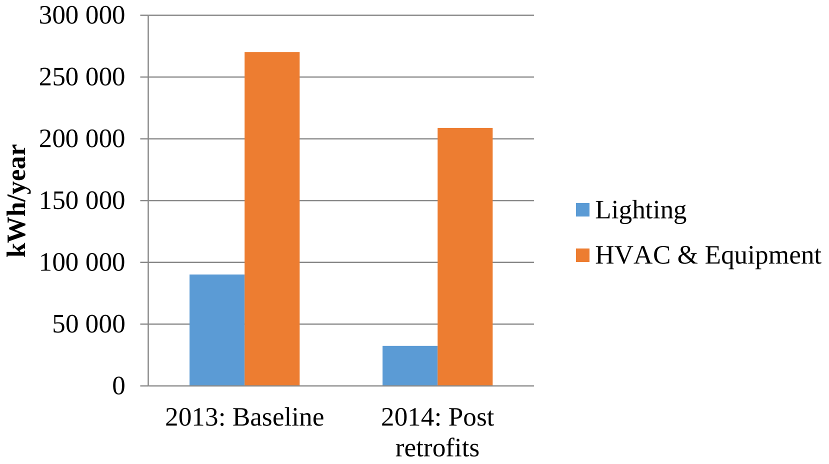

Figure 5.12: Omni Forum retrofit project baseline before EE & RE interventions and impact of EE & RE interventions

Table 5.4 provides a summary of the three buildings that have received both energy efficiency and renewable energy interventions. Gallows Hill was the first building identified for a solar PV intervention due to its location, as this building is situated in the heart of the City and is quite accessible to the public. Gallows Hill PV system was developed during a period when grid tied systems were only accepted by the City of Cape Town's electricity services department with a throttling mechanism in place, to prevent any excess power from being fed back to the grid. The Environmental Resource Management Department was the first City of Cape Town department to develop tender specifications for PV systems. This was a steep learning curve as there were a number of factors to be considered while ensuring that good quality technology was procured. Developing the correct tender specifications was crucial. Gallows Hill building roof space availability could only accommodate a 10kWp PV system.This is one of the constraining factors with rooftop based PV systems. The total cost of the system was R27.62/Wp. Comparing the two projects and looking at

Table 5.4, it can be seen that the Royal Ascot and Omni Forum project took 1 year and 3 months longer to complete than the Gallows Hill PV project. Prices internationally for solar PV have been on a steady decline and can be seen in the procurement prices for the two projects. The Royal Ascot and Omni Forum projects price was R6.2/Wp cheaper than Gallows Hill. This price decrease occurred within one year.

Table 5.4: Summary of PV projects with EE interventions during phase 4

BUILDING NAME	GALLOWS HILL	ROYAL ASCOT	OMNI FORUM
Energy Efficiency interventions before	LED Lighting, occupancy sensors and smart meter	LED Lighting, occupancy sensors and smart meter	LED Lighting, occupancy sensors and smart meter
Length of process (Investigation to commission)	1 year and 2 months (March 2013 to May 2014)	2 years and 6 months (June 2013 to December 2015)	2 years and 7 months (June 2013 to February 2016)
Manner of installation	Bolted on concrete flat roof (sealed waterproofing)	Bolted to concrete slabs on flat concrete roof (no waterproofing required)	Clasped to 'corrugated' flat roof top sheet with 'Solar Roof Longline type interface' clasp
When commissioned	May 2014	December 2015	February 2016
System installed	Grid tied		
Floor Size in square meters	126m^2	183m^2	775m^2
Size in kWp	10 kWp	20 kWp	60 kWp
% of total electricity supplied by renewable energy	2% Renewable Energy	7% Renewable Energy	20% Renewable Energy
% of electricity savings	18% Energy efficiency	25% Energy efficiency	16% Energy efficiency
Total Cost of system (Rands)	R276 294	R1 713 762	
Investment cost R/Wp	R27.62/Wp	R21.42/Wp	

kWh renewable energy generated per year	14 137	22 976	61 346
kWh savings per year	107 076	76 968	57576
Financial savings per year	R 14,306 Renewable Energy (R 142,797 with Energy Efficiency)	R 27,571 Renewable Energy (R 119,933 with Energy Efficiency)	R 73,615 Renewable Energy (R 142,706 with Energy Efficiency)

The key lessons learnt in this phase are that a holistic approach had to be taken, in order to ensure the savings would be sustained, but most importantly, to ensure the move away from dependence on grant funding. The City of Cape Town has the capacity and ability to implement energy efficiency by making smarter and more informed decisions and using its buying power to good effect. The Phase 4 energy efficiency buildings projects have seen a bottom up approach being taken by the Environmental Resource Management Department, focusing on getting the technical aspects such as the establishment of baselines for each building, developing and internal data monitoring system of the savings, incorporating training and behaviour change programmes and renewable energy systems correct. At the same time, the Specialised Technical Services Department is showing its willingness to adapt to managing these new technologies. A top-down approach is required in order to enable departments to make sustainable technology choices and change their current business as usual processes.

5.5 Comparative analysis of extent to which the various City of Cape Town Department have implemented energy efficiency programmes

In order to answer research question 1, a set of criteria was developed to assess to what extent the current energy efficiency programme have been implemented across the Electricity Services, Traffic Signal and Specialised Technical Services Departments. The methodology and criteria developed are explained in Chapter 3. The same criteria have been applied to all three departments. The criteria listed in

Table 2 indicate the level to which the department has adopted and embedded the new energy efficient technology in their business processes. Assessing the kWh saving achieved in each sector is not a good enough indicator to determine the level of change that has occurred. Table 5.5 presents the results of the criteria applied to the three departments.

Table 5.5: Comparative analysis of extent of implementing energy efficiency within City of Cape Town Departments

Criteria			**Department score**		
			Electricity Services Department	**Traffic Signal Department**	**Specialised Technical Services Department**
1. Have the store stock items been upgraded to stock the energy efficient product item? (How energy efficient is this product item?)	**Comment**	**Yes/ No**	Yes		Yes
	Weight	**20**	20	20	20
2. Has the entire old product item (in-efficient) been removed from the stores?	**Comment**	**Yes/ No**	No	Yes	Yes
	Weight	**40**	0	40	40
3. Has the technology been changed in the store stock items to being completely energy efficient?	**Comment**	**Yes/ No**	No	Yes	Yes
	Weight	**25**	0	25	25
4.Has the department changed their business as usual approach to being more energy efficient?	**Comment**	**Yes/ No**	No	Yes	No
	Weight	**10**	0	10	0

5. Has the department's staff been trained to maintain the new technology?	**Comment**	**Yes/ No**	Yes	Yes	Yes
	Weight	**5**	5	5	5
Total		**100**	**25**	**100**	**90**

Table 5.5 illustrates that the Electricity Services Department has not adequately adapted their business operations to being energy efficient. A comprehensive analysis was conducted by the Environmental Resource Management Department to assess whether the store stock items were changed to ensure that the new energy efficient technology was now being stocked in the stores. All Departments that participated in the Energy Efficiency Demand Side Management programme formed part of this review. The full report on the store stock items can be found in Annexure A. The report revealed that all the inefficient street lighting items, such as the mercury vapour (MV) fittings, are still stocked in the stores. There is no reason why these inefficient stock items are required when the aim and intent of the energy efficient retrofits was to change the technology. Departments have the ability to make stock items redundant and stock what they require. The store stock items need to reflect a change in order for true energy efficiency to become the new business as usual.

The Electricity Services Department understands that, with the introduction of any new technology, capacity building and training is required in order for their staff to maintain this technology. The overall weighting reflects that, although the Electricity Services Department participates in the Energy Efficiency Demand Side Management programme, they are not adapting their business operations in order to only stock energy efficient technology. This needs to be addressed, as this implies that the current savings being realised will be lost over time, as they will be defaulting to using the inefficient technology being stocked.

Applying the same set of criteria to the Traffic Signal presents a very different result from that of the Electricity Services Department. The Traffic Signal Department recognised at a senior management level the need to change their business as usual model and become more energy efficient. A review of the store stock items revealed that all incandescent and halogen light bulbs were removed and that the Transport department now stocked the new traffic Light Emitting Diode lights (see Annexure A). As previously stated, the financial and electricity savings are obvious benefits associated with energy efficiency programmes. The Traffic Signal Department recognised the other technical benefits associated with switching to Light Emitting Diodes. These benefits include lower operational expenses and lower long-term maintenance on traffic lights. The new technology received fewer errors at intersections, meaning that less staff was required to be on standby. The operational benefits for the department was seen as important, hence the drive to change the technology. It is important to recognise the relationship and role that the Environmental Resource Management Department had with the Traffic Signal Department. The Environmental Resource Management Department did not get involved in the technical aspects of the project. The Environmental Resource Management Department merely ensured that the funds were administered according to the funding requirements, and that the data was collected for reporting purposes. The Traffic Signal Department took the lead in designing and changing their operational business process. They recognised that their staff would require training, that the store stock items needed to be amended and that their management of the system would require a changed business process. Table 5.5 illustrates that the Traffic Signal Department achieved a total score of 100, as they have managed to change their business process to being sustainable.

Applying the same set of criteria to the Corporate Services, Specialised Technical Services Department, from Table 5.5, it can be seen that they achieve a score of 90. The lighting stock items are the only items stocked which required replacement with an energy efficient stock item. This was done by Environmental Resource Management Department. Specialised Technical Services scores a total of 90 due to most of the processes developed by Environmental Resource Management Department. The Specialised Technical Services Department is gradually starting to take ownership and develop their own processes in order to continue implementing energy efficiency where possible. A key area that requires work is the manner in which materials are procured. For example, Heating Ventilation Air Conditioning equipment is not stocked in the City of Cape Town stores. Specialised Technical

Services is not procuring the most energy efficient Heating Ventilation Air Conditioning systems for the City of Cape Town buildings. Lighting is the only material that has been changed in the City of Cape Town stores and is being procured as the most energy efficient technology by Specialised Technical Services. This indicates that the collaborative relationship between the two departments is yielding results.

5.6 Summary

Momentum has been built over the years through project implementation of energy efficiency projects across all the key departments within the City of Cape Town's internal operations. It is evident that having a dedicated team driving and facilitating energy- and climate-change related matters, has enabled a coordinated approach to energy efficiency within the City of Cape Town's internal operations. A key driver in transforming all the traffic lights to LEDs is the reduced maintenance and the financial savings achieved. The traffic lighting LED technology from a systems perspective was simpler to adapt and change, the technology was merely a plug and play scenario, no major re-design of the current system was required which was a key benefit in making the argument to retrofit all of the traffic lights. The foundation has been set with key lessons learnt from the projects implemented and through working with other departments. The following chapter aims to present the results of the business model developed and applied to two pilot departments, in order to ensure energy efficiency programmes are sustained beyond the guaranteed funding period.

6 Results – Proposed future business model

This chapter presents the proposed future business model to ensure that he City of Cape Town's internal operations adopt a business process that would capitalise and build momentum on the initial foundation that has been established. This would allow the City of Cape Town's internal operations to follow a path that is sustainable and ensure that the City of Cape Town continues to lead by example through its implementation of energy efficiency and renewable energy programmes. This chapter further illustrates how this business model would work by applying the business process methodology developed to two internal departments.

6.1 Energy targets and business plan developed for Sports Recreation and Amenities Department

The Sport Recreation and Amenities department is responsible for over 582 sports and recreational facilities across the City of Cape Town. It consumes 15 097 007 kWh per annum of the electricity of the City of Cape Town's buildings and facility electricity consumption. This department has a very complicated business model, as it leases most of its facilities to the public. Figure 6.1 illustrates the electricity consumption profile over the past five years. Electricity consumption has been on a steady increase over the past five years. The challenge with this department is that one cannot immediately state that this increase in electricity consumption is because of bad management. It could be that the usage of the facility by the community has increased. Further investigation on the facility usage patterns would be required in order to confirm the factors that have contributed to this steady rise in electricity consumption. Figure 6.1 does allow one to indicate that there is an opportunity for energy efficiency initiatives to reduce the current electricity consumption trend.

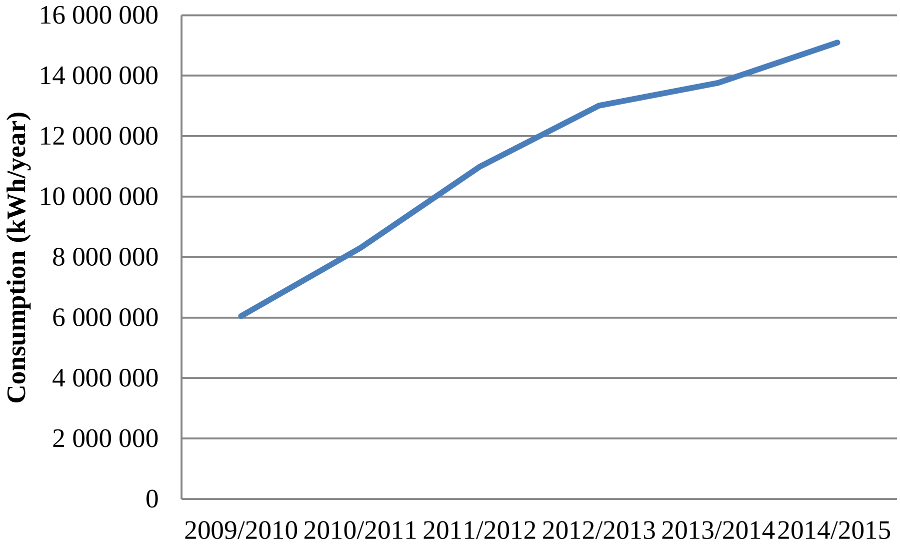

Figure 6.1: SRA electricity consumption over the past 5 years

Figure 6.2 presents the results of the energy audit data of the twelve categories of facilities audited. The energy audit data collected assisted in determining the electricity consumption distribution per facility category. The energy audit data results are twenty eight percent higher than the SAP metered data. This is due to estimating the operating hours which was used in the audit method. Operating hours of equipment in a facility is the most challenging variable to determine and it is too costly to place sub meters on all the various equipment in a facility. The auditor has to conduct interviews with the facility managers to assess the number of hours specific equipment is used in the facility. Results from an energy audit obtained will differ from actual metered data and it is due to the operating hours determined and used in the energy audit. The energy audit data results assisted in establishing the electricity consumption distribution by facility. This data assisted in apportioning the total electricity consumption meter data from SAP.

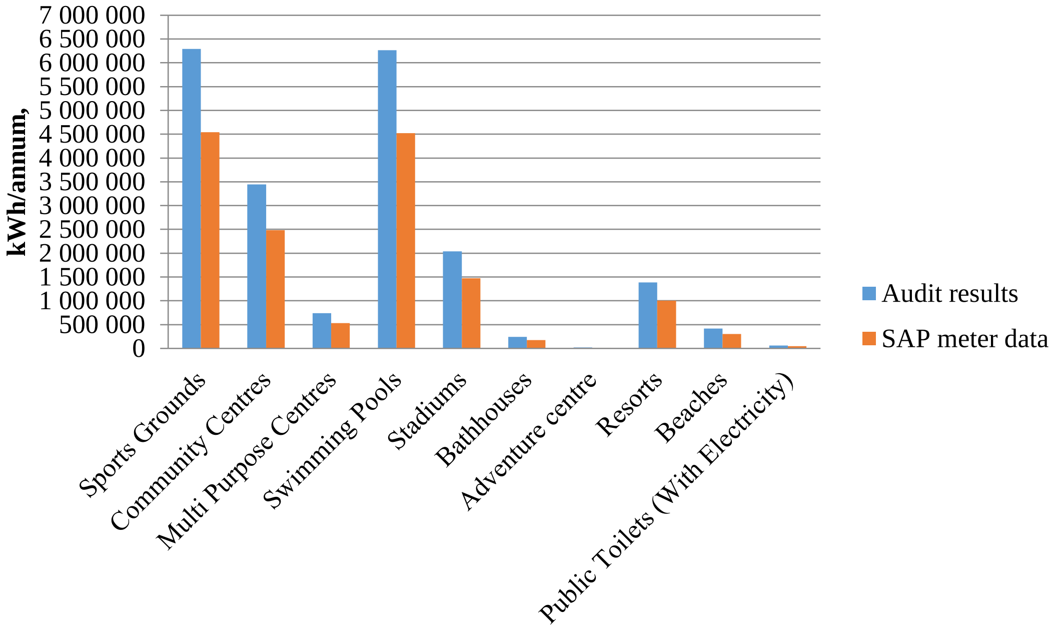

Figure 6.2: Results for average annual electricity consumption from audit results vs metered data on SAP system

Figure 6.2 assisted in developing Figure 6.3 to 6.7. Figure 6.3 illustrates the electricity consumption per category for the Sports, Recreational and Amenities (SRA) department. This graph illustrates which of the facilities consume the most electricity. This graph assists in ranking the departments from an electricity consumption perspective. Sports Grounds, Community Centres and Swimming Pools consume the most electricity. This assists in prioritising where to start focusing energy when developing the business plan.

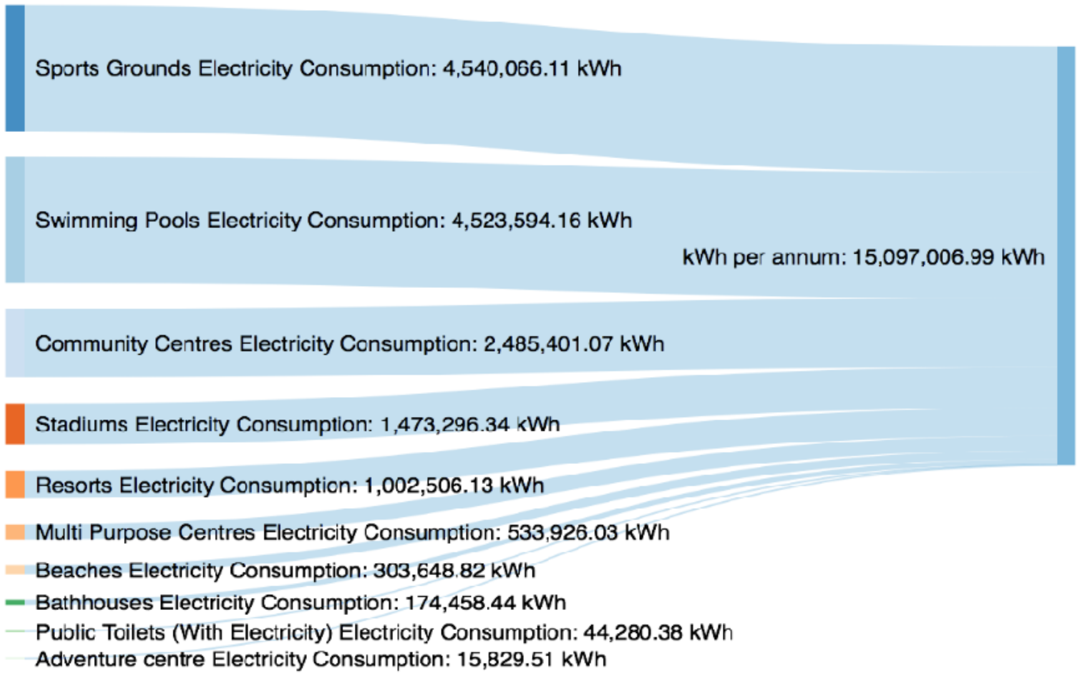

Figure 6.3: Electricity consumption distribution for Sports Recreation and Amenities facilities

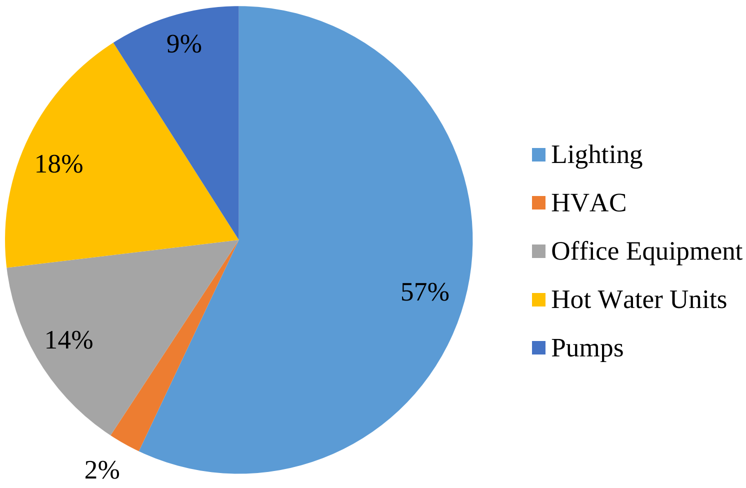

Figure 6.4: Overall electricity consumption distribution by equipment type in Sport and Recreation facilities

Figure 6.4 illustrates the overall consumption distribution of electricity by various equipment devices used in Sports and Recreational facilities. This immediately assists in recognising that lighting, hot water and office equipment are the key initial areas to focus on. Efforts and inerventions can be focused on equipment which is the most energy intensive this will yield in maximum savings being realised through reducing the most energy intensive equipment. Caution needs to be exercised, as it is not advisable to develop the business plan on this overall consumption distribution of electricity by equipment graph. From the field work and interviews conducted with the Sports Recreational and Amenities department, we were informed that Swimming Pools are quite electricity intensive. Therefore, using the three top electricity consuming category facilities identified from Figure 6.4, one can establish the key equipment types to focus on when developing the business plan. Figure 6.5 illustrates that lighting consumes the primary amount of electricity at Sports Grounds. Energy efficiency measures within Sports Grounds should start with energy efficient lighting and energy management of the facility.

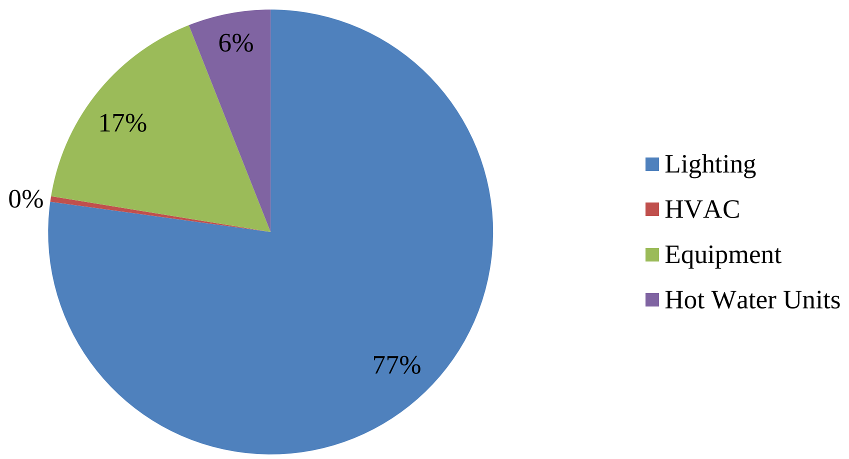

Figure 6.5: Sports Grounds electricity consumption distribution by equipment type

Figure 6.6 illustrates the distribution of electricity consumption by equipment type for Swimming pools. Pumps consume the most electricity in these facilities, then lighting and hot water. Most of the Swimming pools are heated by resistive elements built into swimming pools and hence hot water is an important equipment type when implimenting energy efficiency measures. In developing the business plan all three predominant equipment types need to be accounted for.

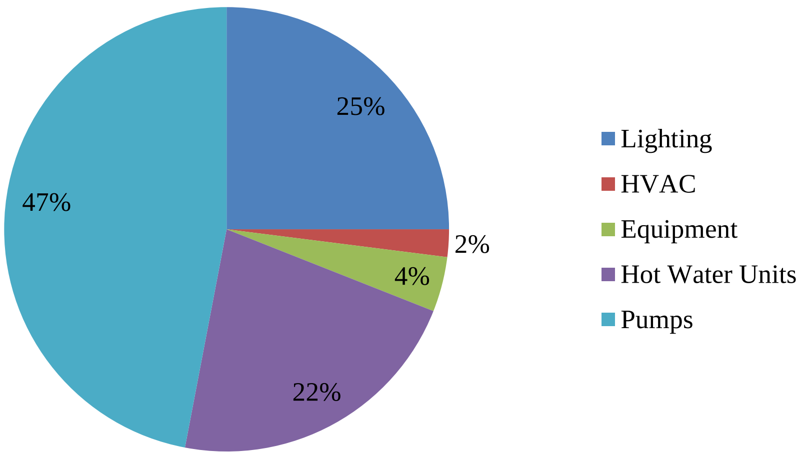

Figure 6.6: Swimming pool electricity consumption distribution by equipment type

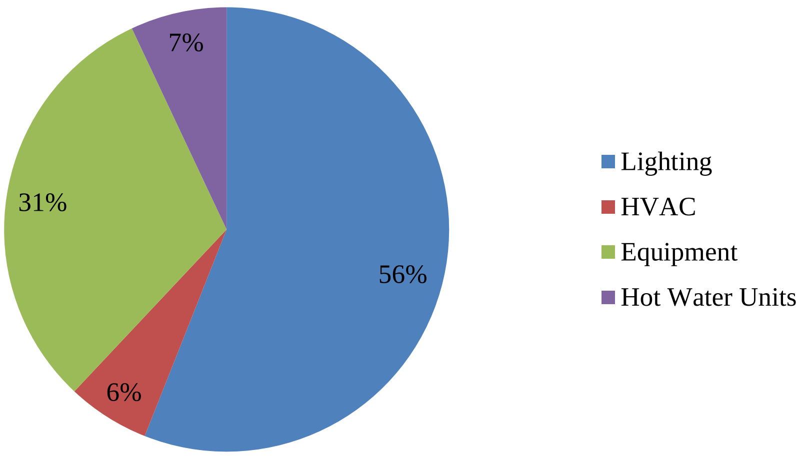

Figure 6.7: Community centres electricity consumption distribution by equipment type

Figure 6.7 illustrates the electricity consumption distribution by equipment type for Community Centres. Lighting and office equipment are the most electricity consuming equipment types in this facility, and these two equipment types will be considered when developing the business plan for Sport Recreation and Amenities Department.

The Sports Recreation and Amenities Department have not implemented any energy efficiency interventions. The baseline year of 2014 has been selected, as this was the only up to date and complete data available. The five year period will commence upon formal acceptance and budget support received. The following five year business plan and energy target was developed for the Sport Recreation and Amenities Department; Table 6.1 illustrates the business plan.

Table 6.1: Sport Recreation and Amenities Department five year period business plan and energy target developed

Priority Facility Categories	Interventions	Savings from intervention (kWh/annum)	Savings from interventions (Rand/annum)	Investment Cost (Rands)	Simple Payback Period (years)	Target Savings %
Sports Ground, Community Centres and Swimming Pools	Energy Efficient Lighting	1 291 473	1 859 722	28 412 416	15	**17**
Swimming Pools	Hot water	564 553	812 956	1 298 472	2	
	Pumps	408 525	588 276	7 353 450	13	
All SRA facilities	Smart metering	50 smart meters per annum		2 500 000	N/A	
SRA staff	Capacity building and training	150 970	217 397	500 000	N/A	
SRA staff and tenants at facilities	Awareness raising and Behaviour Change programme	150 970	217 397	500 000	N/A	
	Total	**2 566 492**	**3 695 748**	**40 564 338**	**11**	

A target of 17%, which aims to save a total of 2 566 492 kWh, has been determined for a five year period against a baseline of 15 097 007 kWh (baseline year 2014) as presented in Table 6.1. The literature review conducted, highlighted the impact of setting of targets (World Energy Council, 2008, 2013; IEA, 2014). This target is achievable for the Sport Recreation and Amenities Department.The interventions identified are easy to implement, and the savings and investment cost is based on past projects, which have been implemented to develop this target. An investment cost of R40 million over a five year period is required to achieve this target. Lighting, pumps, hot water and smart metering are the technologies that have been identified as the initial implementation needed.

This business plan makes provision for capacity building and behaviour change, which will form an integral part in ensuring that the savings from the energy efficient interventions implemented are maintained. The savings determined from the capacity building and awareness raising and behaviour change interventions are calculated to save a cumulative of 301 940 kWh over a five year period. This is two percent off the 2015 baseline year, which is a very conservative estimation. The literature review conducted indicated that from various behaviour change and awareness raising programmes, an estimate of between 5% and 25% savings could be achieved (Radulovic *et al.*, 2011; Boza-kiss *et al.*, 2013; Annunziata *et al.*, 2014). In the absence of a dedicated champion to drive these measures, a very conservative estimated savings for the capacity building and awareness raising and behaviour change interventions has been determined. Achieving a higher saving would result in boosting the morale of staff and encouraging further awareness raising and behaviour change interventions. The payback period of 11 years is considered to be reasonable for this kind of operation and facility.

6.2 Energy targets and business plan developed for Specialised Technical Services Department

The Specialised Technical Services (STS) Department is responsible for the City of Cape Town's 93 large corporate administrative buildings. These buildings service the City of Cape Town's administration and are mainly offices. Unlike the Sport

Recreation and Amenities Department that manages a diverse range of facilities, Specialised Technical Services Department has one type of building it manages, namely corporate administrative buildings.

Table 6.2: Summary of STS building information

Facility Type	Number of facilities	Number of smart meters	Sample Size	Audits conducted	Total floor size in m^2
Large Corporate Administrative buildings	93	70	13	21	266 556

The sample size for Specialised Technical Services Department's buildings was determined to be thirteen. Twenty-one energy audits were conducted in total. This increased audit sample size increases the quality of the data. Specialised Technical Services Department's buildings total floor size was calculated to be 266 556 $m^{2.}$

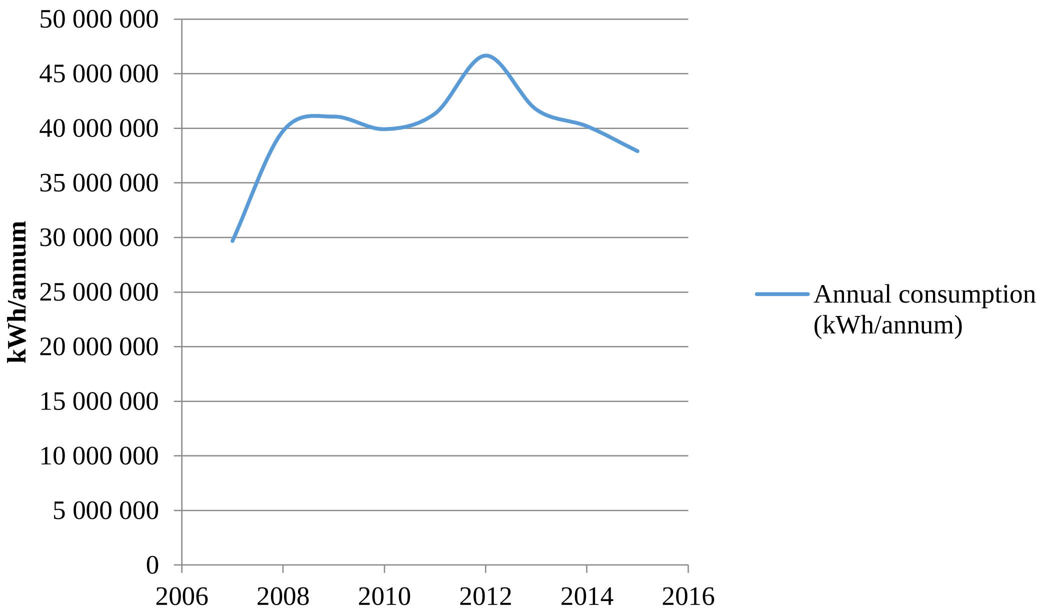

Figure 6.8: Electricity consumption profile for STS buildings

Figure 6.8 illustrates the consumption data from electricity meters. The electricity consumption for the period 2007 to 2009 ranged from 29 to 41 million kWh. The drastic increase in consumption is a result where previously most facilities were not metered and through the implementation of the smart metering programme the electricity consumption improved. Figure 6.8 illustrates two periods where an increase in consumption was experienced in the Specialised Technical Services Department consumption profile namely; 2007 to 2009 and 2011 to 2012. These periods of increase in electricity consumption is attributed to improvement of the data through the smart metering programme. The decrease in consumption experienced in 2010, where electricity consumption was recorded as 39 million kWh, confirms that the energy efficiency interventions implemented during the phase 1 building energy efficiency retrofit programme were effective. The smart metering programme improved the data collected for Specialised Technical Services Department. A key challenge, which is experienced in Specialised Technical Services, is with administrative buildings in the entire facility are not metered. It was often found that only a portion of the facility was metered.

A year-on-year decrease in electricity consumption from 2012 can be seen. This can be attributed to the number of energy efficiency programmes implemented. The close working relationship between the Environmental Resource Management Department and the Specialised Technical Services Department is paying off, as this trend confirms the decrease in consumption. The capacity building and training of facility managers through the fundamental energy management training is another contributing factor to this year on year decrease. The estimated energy efficiency measures implemented in STS buildings between 2012 and 2015 was estimated to generate a total of 7 224 923 kWh of savings during this period. The metered data presented in Figure 6.8 for the period 2012 to 2015, illustrates that a total of 8 752 824 kWh of savings have been achieved. This proves that the improved metering and implementation of an effective energy management system coupled with capacity buildign and awareness training programme yields, the desired outcome. The new baseline for Specialised Technical Services, using 2015 as the baseline year, is 37 902 564kWh. All measures implemented from 2015 onwards will be measured against this baseline. The five year period will commence upon formal acceptance and budget support received and the baseline year will be from 2015.

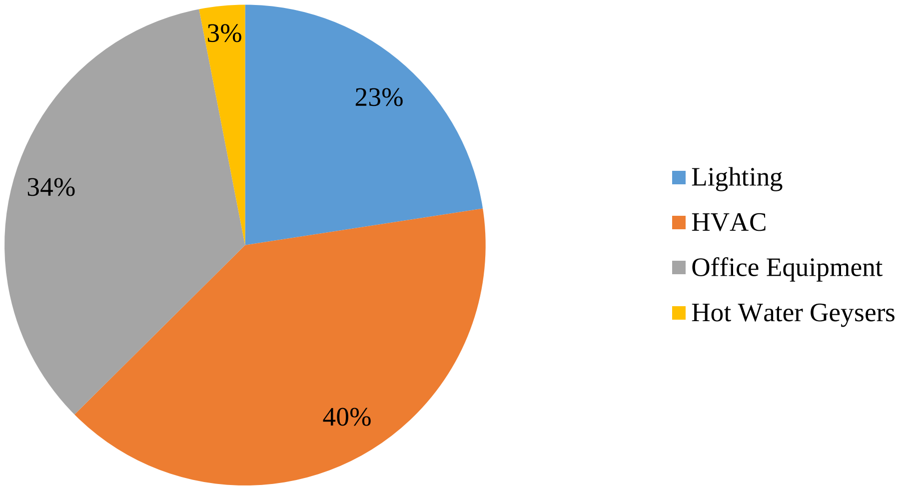

Figure 6.9: Electricity consumption distribution by equipment type of STS facilities

From the energy audits conducted the electricity consumption distribution of the equipment type was determined, as illustrated in Figure 6.9. Heating Ventilation Air Conditioning, office equipment and lighting are the predominant equipment type that consumes the most electricity in these facilities. It is important to state that with office equipment it is most cost effective to manage consumption and educate users on optimal usage of equipment. The business plan will focus on behaviour change and an energy management system, which can be seen as the first cycle in making the office equipment usage more energy efficient.

Table 6.3: Specialised Technical Services Department five year period business plan

Interventions	Savings from interventions (kWh/annum)	Savings from interventions (Rand/annum)	Investment Cost (Rands)	Simple Payback Period (years)	Target Savings %
Energy Efficient Lighting	2 252 470		23 180 097	7	**23**
Hot water	61 230	88 171	630 113	7	
Heating Ventilation Air Conditioning	7 981 956	11 494 016	82 142 040	7	
Smart metering	8 smart meters per annum		400 000	N/A	
Capacity building and training	1 996257	2 874 610	1 000 000	N/A	
Awareness raising and Behaviour Change programme	3 327 095	4 791 017	500 000	N/A	
Total	**15 619 008**	**22 491 371**	**105 952 250**	**5**	

Table 6.3 presents the five year energy efficiency business plan and energy target developed for Specialised Technical Services. A 23% energy savings target has been determined for Specialised Technical Services Department, to be achieved within five years. An investment factor of R10/kWh saved was determined from past projects savings and investment cost (see data in Annexure D). An investment of R105 952 250 over a five year period will be required in order to achieve this target, and will yield positive results in a seven year payback period. Any payback period of 10 years and lower is considered to be a very attractive investment for the City of Cape Town. Specialised Technical Services Department has the capacity to achieve this target, as they are already incorporating, where possible, the principles of energy efficiency in their business process. The development and adoption of an energy target will assist in directing and focusing the efforts of the Specialised Technical Services Department even further.

6.3 Summary

This chapter illustrates the Internal Energy Management Protocol Process, which has been developed as business model, and is illustrated in Figure 4.18 on page 118. This figure illustrates the way in which this business model aims to make policy actionable through the development of departmental business plans and targets. This business plan consists of three layers namely a policy, organisational setting and business plans, and energy targets for departments. All three layers are required in order to institutionalise energy efficiency within the operations of the City of Cape Town. Policy on its own will not drive implementation. The establishment of a resource efficiency sub-working group will ensure that accountability and implementation at a departmental level is achieved. This sub-working group will act as a check and balance. The City of Cape Town has supported this business model by piloting the draft Internal Energy Management Protocol with two departments and supporting the development of this resource efficiency sub-working group. The feasibility of this business model can be determined by a number of tangible indicators. One such indicator is the achievement of the energy targets set for the departments. What this chapter and study did not focus on is the financial mechanisms needed to support the business model developed. This will be a crucial next step to supporting the implementation of this business model.

7 Conclusions and recommendations

This chapter summarises the key findings that could be used as a framework by other municipalities and possibly other government state owned entities to standardise the implementation of energy efficiency within their own infrastructure and operations. Limitations of the study are highlighted and possible suggestions are made with regards to addressing these limitations. A summary of key improvements to the business model developed is also discussed while highlighting future research, which is required in this area.

7.1 Key findings of study

This study has created an understanding on implementing energy efficiency within the City of Cape Town's internal operations and has answered the research objectives set out for this study. The summary of the study's findings is presented as follows, with points a to d summarising all findings pertaining to research questions 1 and 2 of this study:

a) Connecting the literature with practice

A detailed review of the literature ensured that the barriers, lessons learnt and best practices in the field of energy efficiency within the municipal context were confirmed. Energy efficiency interventions and programmes are closely linked to climate change mitigation targets, and the argument to drive energy efficiency is made from a financial and environmental perspective. The City of Cape Town has followed this international trend by making the benefits of implementing energy efficiency visible within the organisation, through development of a data monitoring and reporting system, as well as the development of energy and carbon targets through its policy framework. This process has proven to be instrumental. The case study chapter presented in section 4 from page 74 to 120 assessed the energy efficiency programmes implemented by the City of Cape Town to date. The case study revealed that in practice linet departments are still only concerned about the financial and staff implications of projects. Therefore, any benefits or programmes or processed developed needs to illustrate how it will positively impact the financial and staff component of departments.

Chapter 5 presented the results and the impact of energy efficiency interventions implemented in the City of Cape Town's internal operations. The results confirmed the findings in the literature review section. Easily implemented measures such as energy efficient street, traffic and building lighting interventions yield high savings. Street and traffic energy efficient lighting are not complex to implement. Energy efficient building programmes are more complex therefore there is a need for an energy audit, over and above smart metering in order to develop a baseline and confirm savings. This requires a re-think of the manner in which the benefits of energy efficiency projects are presented to different actors within the organisation. The monitoring and data collection requires a different and a more robust approach to ensure that, over and above the energy and financial savings being recorded, the maintenance and staff benefits are taken into account.

A municipality is a complex system which influences and is influenced by its surrounding. A municipalitites mandate as stated in the constitution states that a municipality has to deliver sustainable services; this was further discussed and highlighted in section 2.6 page 40 of this thesis. A municipality has the role of creating an enabling framework and executing national governments goals and targets through its services and development plans it approves within its respective municipality. This function and mandate as defined and explained in detail in section 2.6 on page 40 gives credence to the ability a municipality has to influence sustainable development by other sectors. The internal operations of the City of Cape Town, although a small energy user within the greater energy picture of Cape Town, has the ability to influence large energy consuming sectors such as the residential and commercial sector as it manages development and roles out services to these sectors as explained and highlighted in detail in section 2.6 on page 40. This ability to lead by example, which local government has, remains a key aspect in driving and solving the current climate change challenges faced globally.

b) Data access and collection

The City of Washington DC, in the USA achieved an 8% saving through the implementation of energy data management system. This energy data management system also consolidated and made it easier for internal departments to access their energy data. The City of Cape Town is developing a system similar to that of the City of Washington, DC with the same intent of making it more accessible and mange energy consumption more effectively.The results section 5 on page 121illustrates the importance of data collection, monitoring and reporting of projects.Data remains the most important aspect in developing, managing or implementing energy efficiency within the municipal context as explained in section 2.3 page 26 and section 4 page 74 to 120. This study highlighted the need for an integrated and consolidated data system within the City of Cape Town's internal operations, in order to effectively monitor and manage its internal energy consumption. This study revealed that there is a lot of available data in the City of Cape Town's systems. The real challenge has been the fragmented systems that the City of Cape Town has. The task of weaving together a department's energy profile is a colossal one, as the energy data lies in many fragmented systems. The development of an integrated and consolidated energy data management system within the City of Cape Town will unlock many opportunities to further implement energy efficiency interventions. The City of Cape Town's energy data management system will be a one stop system where all energy data is displayed. Departments will, for the first time, know what their total energy consumption is. This will enable a number of behaviour changes and basic energy management opportunities, which will lead to further energy savings being realised.

A unified approach and a central data collection system remain important. This study has presented the data collection system and approach developed by using actual metered data and energy audit methodology, in order to develop a complete energy picture for each department.

c) *Organisational framework and policy*

Understanding the organisational framework and existing policy landscape is also important. This assists in identifying the gaps in both existing organisation's framework and policy. This study concluded that the City of Cape Town has good policy in place to support resource efficiency. The development of new policy is not required. However, it is in the interest of the Environmental Resource Management Department to partner and support Property Management's Immovable Property Asset Management Policy.

Finding such synergies is crucial, as both departments want to institutionalise resource efficiency. The reasons are different for each department, but the final result is the same. This kind of collaboration and support breaks down the usual perception of government departments working in silos. The City of Cape Town has set in place a governance structure to support a more transversal approach within the organisation. This is in the interest of improved service delivery and better management of resources. In the overall interest of wanting to institutionalise resource efficiency within the municipal operations, leading departments need to find synergies where possible, and support the organisation's overall agenda to not duplicate efforts and waste energy.

d) The need for champions and drivers and capacity development

This study has proven that with a dedicated unit and a dedicated individual staff member appointed, continuous implementation of energy efficiency and savings has been realised this has been explained in detailed in section 4 page 74 to 120. Having a dedicated team of champions or drivers is a requirement in order to ensure that energy efficiency becomes business as usual within the City of Cape Town's internal operations further examples are given in section 2.3 page 26.. These dedicated teams and individuals assist other departments to understand their energy consumption. Furthermore, they assist them in identifying key interventions needed in order to reduce their consumption and improve their infrastructure from a sustainable development perspective. To illustrate the need for departmentmental accountability and the need for champions has been illustrated and explained in sections 2.3 page 26 and section 4 pages 74 to 120. Departmental key performance indicators around energy efficiency and dedicated champions within City of Cape Town's departments is required to ensure further penetration and a greater scale of implementation is achieved.

Development of staff capacity around resource efficiency is likewise important. This study has proven that the capacity building training conducted with the Specialised Technical Services Department has resulted in a year on year electricity consumption reduction for Specialised Technical Service Department. This internal capacity development with regards to energy management is crucial from both a technology management point of view, and in unlocking further energy efficiency interventions.

e) Business model

The development of a business model to implement energy efficiency was important and aimed to answer research question 3 of this study. The following key finding and recommendations are to be considered in view of the results obtained. The business model in the municipal context is the Internal Energy Management Protocol, as illustrated by Figure 4.18 on page 120. This allows for a unified business process, to be followed by all City of Cape Town departments wanting to implement energy efficiency. This ensures that efficiency is obtained and assists in monitoring and reporting of the interventions, as a more uniform process is followed.

The business model was applied to two pilot departments namely: Sports Recreation and Amenities and Specialised Technical Services Department which is present in section 6 page 140 to 153. The Sports Recreation and Amenities Department, a target of 17% savings was determined off Sports Recreation and Amenities 2014/15 electricity consumption as the baseline year. Specialised Technical Services a target of 23% savings was determined off their 2014/15 electricity consumption as the baseline year. The two departments are very different, therefore understanding the interventions to be pursued in each department is important. Sports Recreation and Amenities would be required to focus on retrofitting their lighting to energy efficient lighting, whereas Specialised Technical Services will be focusing on heating ventilation and air conditioning systems to be retrofitted. In section 2 page 20 to 26 examples of energy efficiency interventions were given and explained with further examples illustrated in section 4.6 page 86.It is anticipated that higher savings can be realised through retrofitting of heating ventilation and air conditioning systems than lighting in a buildings this was illustrated from the past projects implemented in section 4.6 page 86 . Developing an investment cost factor based on past projects resulted in realistic payback periods for each department. The estimated payback period of five years determined for Specialised Technical Services, compared to the actual seven year payback period realised in past projects, is in line with what is expected. The utilisation of departmental energy targets works well as this supports the overall internal City operations energy targets developed.

The business model highlights another key aspect, which is that, over and above the development of a department energy target, the financial estimation of the cost of achieving this target is also important. In the absence of understanding the investment cost required, the appropriate financial mechanism cannot be pursued. This proves to be a key finding of this research.

7.2 Limitations of the study

This study only looked at electricity efficiency within the City of Cape Town's internal operations. The project has been implemented, primarily in the Electricity Services Department, Specialised Technical Services Department and Traffic Signal Department, between 2009 and 2016. This does not mean that other departments have not been implementing energy efficiency measures during this period. The other limitation is access, and whether other departments other than the three departments which formed the focus of the study, have captured the impact of their interventions. The findings of this study can be limited to the municipal context. The City of Cape Town is a metro and therefore not all the findings of this study will not be relevant for smaller and district municipalities. The framework presented of this study will be relevant for all municipalities but the detail and how it is applied will be dependant on the specific municipality.

The researcher being both an implementer working for the City of Cape Town, and the conductor of the research, found that time became a constraining factor, as the researcher had to complete her day to day operational working tasks associated with her job at the City of Cape Town and working on her masters thesis. Another limitation is the objectivity of the researcher throughout the study. Being immersed in this research problem, both from an operational and implementation aspect, has at times made it difficult for the researcher to understand what is required purely for research purposes. The blurring of lines between academic requirements and the requirement of implementation at the coalface has proven to be problematic at times.

7.3 Recommendations

This research has enabled an understanding of the requirements necessary in order to institutionalise energy efficiency within the City of Cape Town's internal operations. In order to achieve this, there remain further areas of improvement and further research required. This is summarised as follows:

a) *Improvements to business model*

During the development of the business model it was discovered that there is a need for improved data with regards to the investment cost factor which is the total cost of the technology and the savings associated with this investment cost, this is further explained in section 3.2 page 55 and section 6 pages 140 to 153 A larger data set is needed in order to validate the investment cost factor for a specific period, while updating this investment cost factor data to be used for future investment cost projections. This is an area that will require further research, as the kind of interventions implemented, the savings achieved and more data on investment per technology type is required in order to develop an investment cost factor. This data set will need to be improved and a larger sample size is required, in order to ensure reliability on the establishment of an investment cost factor per technology type.

b) *Data collection and monitoring*

The energy data management system being developed and implemented will take time to display a metered based electricity consumption baseline and reflect the impact of interventions, as this is dependent on the rollout of smart meters. To overcome this challenge the Environmental Resource Management Department has developed a theoretical methodology in order to determine a department's electricity consumption as explained in Chapter 3 of this study. What is still lacking is a tool or methodology that will assist the Environmental Resource Management Department to track and determine the energy efficiency interventions of all internal City of Cape Town Departments. The City of Cape Town has 102 Departments, and only 3 have been monitored holistically in terms of energy efficiency. The collective impact is not known. In the absence of metering, a much more robust methodology is required in order to capture the impact of all internal City of Cape Town departments.

c) *Keeping updated with technology improvements*

It is recommended that all City of Cape Town internal Departments conduct a detailed market analysis study every two to three years, in order to ensure that they are informed of technological advancements occurring in areas such as building energy efficiency, traffic lights, street lights and waste and bulk water treatment plants. This will ensure that the City of Cape Town is informed of technological changes and can adapt its business processes accordingly when upgrades are due or technology needs to be purchased.

d) An in-depth analysis into behaviour and raising awareness

An in-depth analysis and study is required into the kind of awareness and behaviour change interventions required within the internal operations. The literature is lacking on this topic. Only very specific and small study areas in the municipal internal operations are available. A detailed analysis on the organisation as a whole, the various actors and their roles and needs, is required. From this research then, the most effective behaviour change and awareness raising methods and tools should be suggested per audience type within the internal municipal operations. The kind of behaviour and awareness raising methodology needs to show how this will be sustainable and assist in achieving or leading towards improved and further energy efficiency savings. The monitoring and verification of behaviour change and awareness raising interventions also needs further research.

e) The financial detailed analysis and funding mechanism

This study has developed a business process and a methodology in order to give an indicative investment cost required to achieve savings. In the municipal operations field the financial mechanisms needed to support these interventions has not been implemented in a holistic and co-ordinated manner. Now that the investment cost has been identified this detailed financial and funding mechanism is required to ensure that the municipality understands and is aware of the options to consider and to understand the benefits and limitations of each funding mechanism available.

In order to ensure that the South African government achieves its 42% carbon reduction target by 2025 would require all sectors to actively drive and implement energy efficiency and renewable energy measures. The impact and role that local government can play to achieve this target has been confirmed. Municipalities are a major force in driving and leading energy efficiency and renewable energy, which could ensure that the country meets its carbon targets and continues to develop in a sustainable manner. Municipalities can only truly lead by example if they have changed their own business as usual process to a sustainable business operation as discussed in this study. Municipalities will require dedicated capacity to initiate this process internally. The support and continued guidance by various civil society actors remains a fundamental requirement in order to ensure that our municipalities develop the internal capacity to implement energy efficiency and renewable energy programmes. The policy and role of municipalities to implement sustainable services is clear. Municipalities in South Africa have achieved a lot in the energy efficiency space through the support of National Government and the support of other civil society actors. This collaborative approach needs to continue to further advance the potential savings that can be realised in municipal internal operations.

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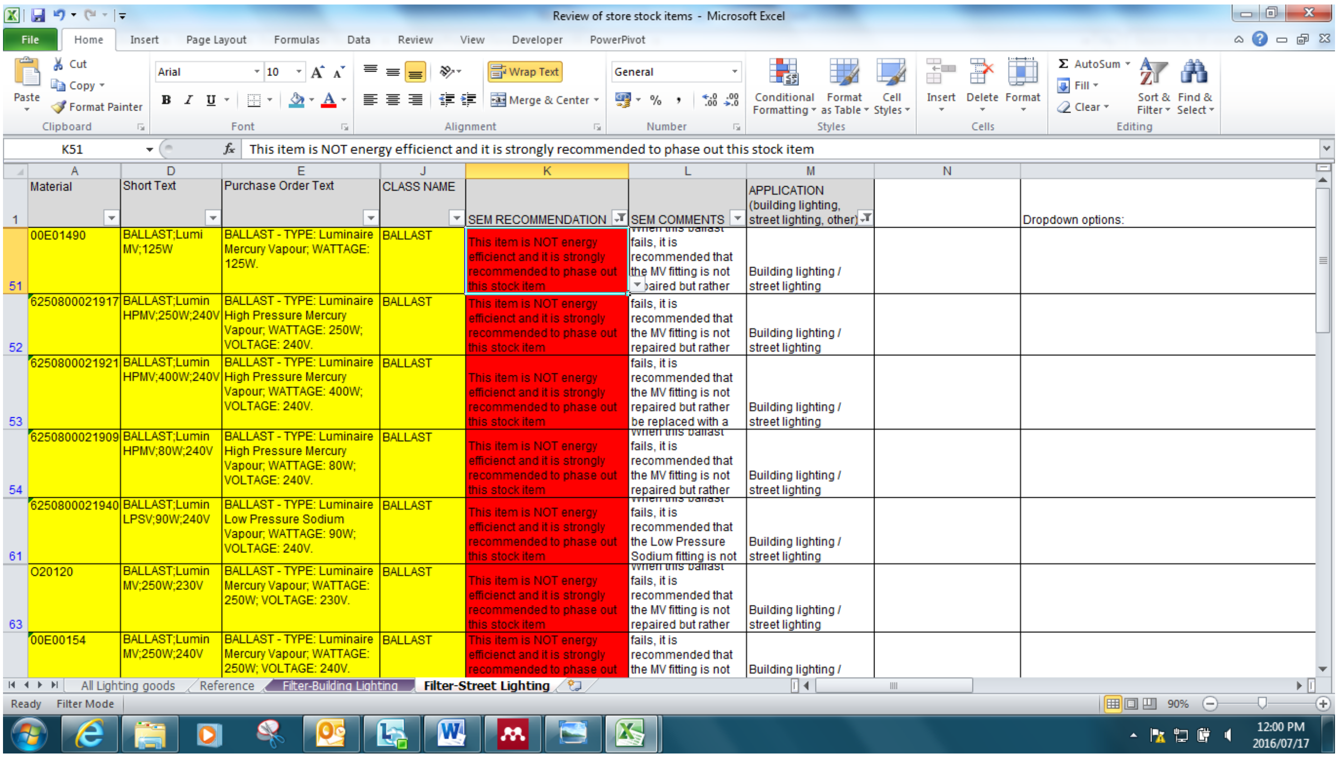
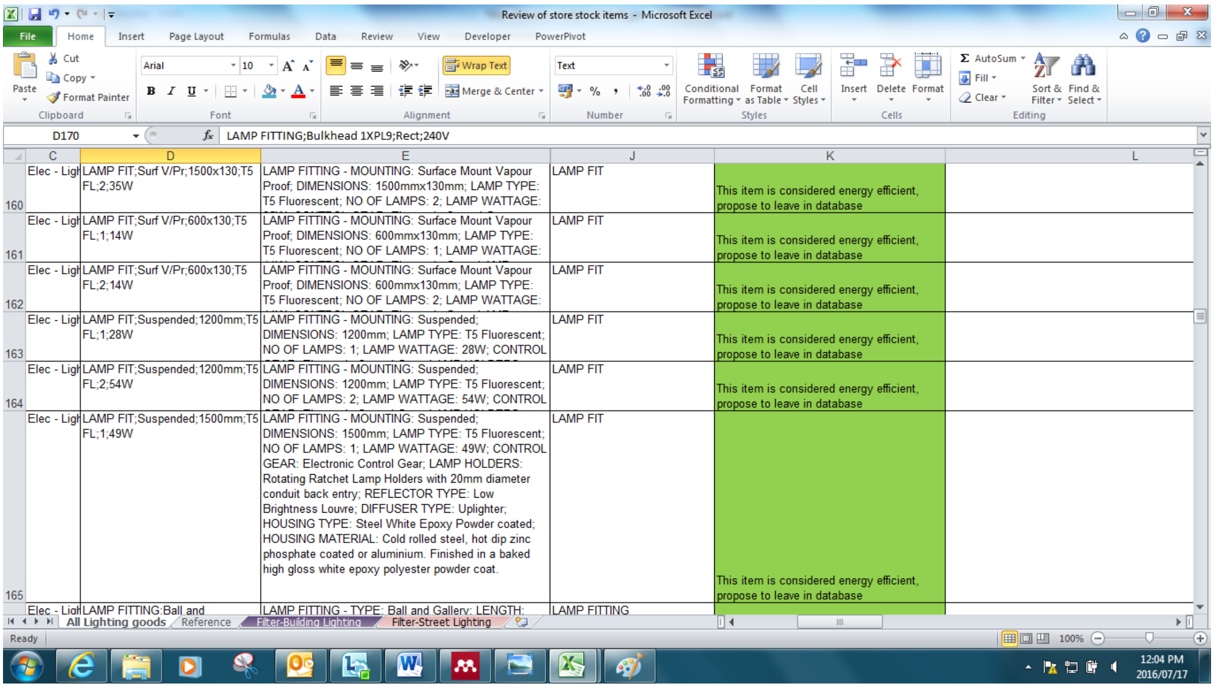
Appendices

Appendix A: Assessment report of departmental store stock items of energy efficient lighting products



Row	Material	Short Text	Purchase Order Text	CLASS NAME	SEM RECOMMENDATION	SEM COMMENTS	APPLICATION (building lighting, street lighting, other)
51	00E01490	BALLAST;Lumi MV;125W	BALLAST - TYPE: Luminaire Mercury Vapour; WATTAGE: 125W.	BALLAST	This item is NOT energy efficienct and it is strongly recommended to phase out this stock item	fails, it is recommended that the MV fitting is not repaired but rather	Building lighting / street lighting
52	6250800021917	BALLAST;Lumin HPMV;250W;240V	BALLAST - TYPE: Luminaire High Pressure Mercury Vapour; WATTAGE: 250W; VOLTAGE: 240V.	BALLAST	This item is NOT energy efficienct and it is strongly recommended to phase out this stock item	fails, it is recommended that the MV fitting is not repaired but rather	Building lighting / street lighting
53	6250800021921	BALLAST;Lumin HPMV;400W;240V	BALLAST - TYPE: Luminaire High Pressure Mercury Vapour; WATTAGE: 400W; VOLTAGE: 240V.	BALLAST	This item is NOT energy efficienct and it is strongly recommended to phase out this stock item	fails, it is recommended that the MV fitting is not repaired but rather be replaced with a	Building lighting / street lighting
54	6250800021909	BALLAST;Lumin HPMV;80W;240V	BALLAST - TYPE: Luminaire High Pressure Mercury Vapour; WATTAGE: 80W; VOLTAGE: 240V.	BALLAST	This item is NOT energy efficienct and it is strongly recommended to phase out this stock item	When this ballast fails, it is recommended that the MV fitting is not repaired but rather	Building lighting / street lighting
61	6250800021940	BALLAST;Lumin LPSV;90W;240V	BALLAST - TYPE: Luminaire Low Pressure Sodium Vapour; WATTAGE: 90W; VOLTAGE: 240V.	BALLAST	This item is NOT energy efficienct and it is strongly recommended to phase out this stock item	When this ballast fails, it is recommended that the Low Pressure Sodium fitting is not	Building lighting / street lighting
63	020120	BALLAST;Lumin MV;250W;230V	BALLAST - TYPE: Luminaire Mercury Vapour; WATTAGE: 250W; VOLTAGE: 230V.	BALLAST	This item is NOT energy efficienct and it is strongly recommended to phase out this stock item	When this ballast fails, it is recommended that the MV fitting is not repaired but rather	Building lighting / street lighting
	00E00154	BALLAST;Lumin MV;250W;240V	BALLAST - TYPE: Luminaire Mercury Vapour; WATTAGE: 250W; VOLTAGE: 240V.	BALLAST	This item is NOT energy efficienct and it is strongly recommended to phase out	fails, it is recommended that the MV fitting is not	Building lighting /

Figure 1: Street lighting review of store lighting stock items



Row	C	Short Text (D)	Purchase Order Text (E)	J	K
160	Elec - Ligh	LAMP FIT;Surf V/Pr;1500x130;T5 FL;2;35W	LAMP FITTING - MOUNTING: Surface Mount Vapour Proof; DIMENSIONS: 1500mmx130mm; LAMP TYPE: T5 Fluorescent; NO OF LAMPS: 2; LAMP WATTAGE:	LAMP FIT	This item is considered energy efficient, propose to leave in database
161	Elec - Ligh	LAMP FIT;Surf V/Pr;600x130;T5 FL;1;14W	LAMP FITTING - MOUNTING: Surface Mount Vapour Proof; DIMENSIONS: 600mmx130mm; LAMP TYPE: T5 Fluorescent; NO OF LAMPS: 1; LAMP WATTAGE:	LAMP FIT	This item is considered energy efficient, propose to leave in database
162	Elec - Ligh	LAMP FIT;Surf V/Pr;600x130;T5 FL;2;14W	LAMP FITTING - MOUNTING: Surface Mount Vapour Proof; DIMENSIONS: 600mmx130mm; LAMP TYPE: T5 Fluorescent; NO OF LAMPS: 2; LAMP WATTAGE:	LAMP FIT	This item is considered energy efficient, propose to leave in database
163	Elec - Ligh	LAMP FIT;Suspended;1200mm;T5 FL;1;28W	LAMP FITTING - MOUNTING: Suspended; DIMENSIONS: 1200mm; LAMP TYPE: T5 Fluorescent; NO OF LAMPS: 1; LAMP WATTAGE: 28W; CONTROL	LAMP FIT	This item is considered energy efficient, propose to leave in database
164	Elec - Ligh	LAMP FIT;Suspended;1200mm;T5 FL;2;54W	LAMP FITTING - MOUNTING: Suspended; DIMENSIONS: 1200mm; LAMP TYPE: T5 Fluorescent; NO OF LAMPS: 2; LAMP WATTAGE: 54W; CONTROL	LAMP FIT	This item is considered energy efficient, propose to leave in database
165	Elec - Ligh	LAMP FIT;Suspended;1500mm;T5 FL;1;49W	LAMP FITTING - MOUNTING: Suspended; DIMENSIONS: 1500mm; LAMP TYPE: T5 Fluorescent; NO OF LAMPS: 1; LAMP WATTAGE: 49W; CONTROL GEAR: Electronic Control Gear; LAMP HOLDERS: Rotating Ratchet Lamp Holders with 20mm diameter conduit back entry; REFLECTOR TYPE: Low Brightness Louvre; DIFFUSER TYPE: Uplighter; HOUSING TYPE: Steel White Epoxy Powder coated; HOUSING MATERIAL: Cold rolled steel, hot dip zinc phosphate coated or aluminium. Finished in a baked high gloss white epoxy polyester powder coat.	LAMP FIT	This item is considered energy efficient, propose to leave in database
	Elec - Ligh	LAMP FITTING;Ball and	LAMP FITTING - TYPE: Ball and Gallery; LENGTH:	LAMP FITTING	

Figure 2: Building lighting review of store lighting stock items

Appendix B: Street lighting energy efficiency data

Table 1: Street lighting retrofits implemented during phase 1 of Energy Efficiency Demand Side Management programme

Lighting technology intervention	Year completed	Current light (W)	Retrofit (W)	Total no of Lights	Savings kWh per annum	% Saving off 2007 baseline
MV to HPSV	2010;2011	80W HPMV	70W HPSV	34 517	2 331 290	10
	2009;2010	125W HPMV	70W HPSV	1 545	1 083 950	
	2009;2010; 2011	250W HPMV	150W HPSV	4 110	2 760 700	
	2010;2011	250W HPMV	100W HPSV	500	301 125	
	2010	250W HPMV	70W HPSV	17	12 286	
HPSV to HPSV	2009;2010; 2011	400W HPSV	250W HPSV	2 346	1 412 879	
	2009	400W HPSV	150W HPSV	320	913 766	
		Total		**43 355**	**8 815 995**	

Table 2: Street lighting pilot LED retrofit part of phase 2 Energy Efficiency Demand Side Management programme

Lighting technology intervention	Year completed	Current light (W)	Retrofit (W)	Total no of Lights	Technical savings kWh per annum
MV to LED	2016	80W HPMV	36 W LED	637	112 532
		125W HPMV	75W LED	4	803
HPSV to LED		70W HPSV	36 W LED	717	97 878
		150W HPSV	75W LED	96	28 908
		250W HPSV	108W LED	124	70 696
		400W HPSV	122W LED	16	17 859
		Total		**1 594**	**328 676**

Appendix C: Data to determine investment cost factor

Table 3: SRA data to determine investment cost per kWh saved

Project description	Savings (kWh)/annum	Savings (Rands)	Investment (Rands)	Investment factor (R/kWh)	Payback	R/kWh investment cost factor
Ocean View A field	40 000	30 800	905 000	22.625	29	22
Ocean View B field	40 000	30 800	905 000	22.625	29	
Browns farm/cross roads sports field	40 000	30 800	796000	19.9	26	
Solo Street Steenberg	40 000	30 800	796000	19.9	26	
Downberg Rd Hanover Park sports field	40 000	30 800	920000	23	30	
Heideveld sports field	40 000	30 800	828000	20.7	27	
Kewtown sports field	40 000	30 800	828000	20.7	27	
Seawinds sports field	50 000	38 500	1199000	23.98	31	
Imizama Yethu Hout Bay Sports field	40 000	30 800	815000	20.375	26	
Total	**370 000**	**284 900**	**7 992 000**	**22**	**28**	

Table 4: Summary of data used to determine investment cost per saving for STS department

Project name	**Year implemented**	**Savings kWh/annum**	**kVA saving/annum**	**Investment (Rands)**	**funding source**	**R/kWh investment cost factor**
Danida- 4 buildings	2010/11	521172		4636524	Grant	**10**
DoRA-14 buildings	2012/13	546595		5358055	Grant	
DoRA-6 buildings	2013/14	555724.78		9422578.82	Grant	
Gallows Hill PV	2013/14	16624		242363	City	
80kWp PV project	2015/16	84322		1713762	City	
Civic Mezzanine	2013/14	936353.77	71.85	20907833	City	
Civic Podium & Tower	2014/15	4288751.4	601	29236401	City	
Total		**6 949 543**	**673**	**71 517 517**		